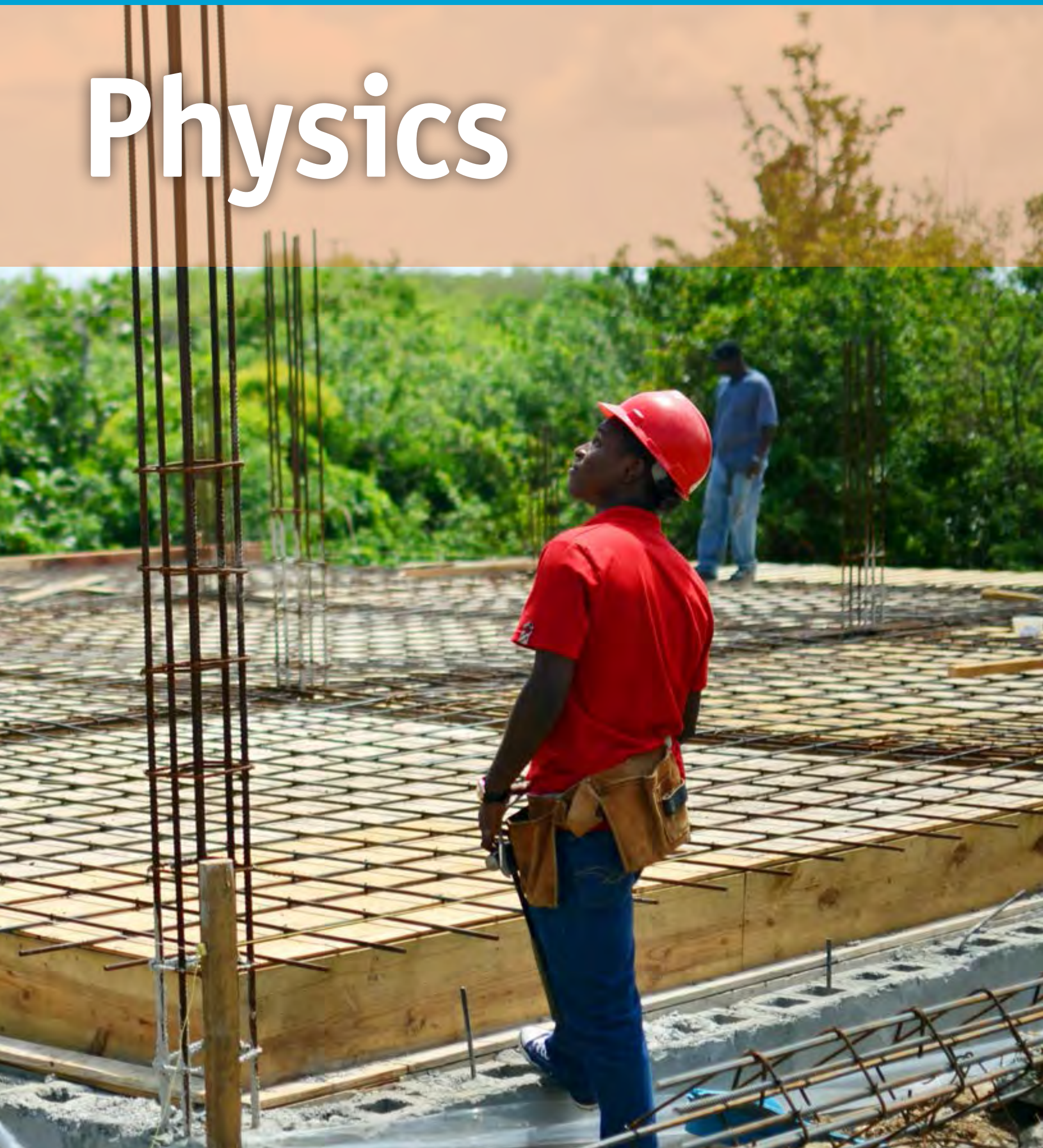
CARIBBEAN EXAMINATIONS COUNCIL

Physics



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CAPE® Physics Past Papers

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TEST CODE **02138010**

FORM TP 2005258

MAY/JUNE 2005

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 01 – Paper 01

1 hour 45 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **NINE** questions. Candidates must attempt **ALL** questions.
2. Candidates **MUST** write in this answer booklet and all working **MUST** be **CLEARLY** shown.
3. The use of non-programmable calculators is permitted.

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
Acceleration due to gravity	g	=	9.80 m s^{-2}
Radius of the Earth	R_E	=	6380 km
Mass of the Earth	M_E	=	5.98×10^{24} kg
Mass of the Moon	M_M	=	7.35×10^{22} kg
1 Atmosphere	Atm	=	1.00×10^5 N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water		=	1.00×10^3 kg m^{-3}
Thermal conductivity of copper		=	400 W m^{-1} K^{-1}
Specific heat capacity of aluminium		=	910 J kg^{-1} K^{-1}
Specific heat capacity of copper		=	387 J kg^{-1} K^{-1}
Specific heat capacity of water		=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice		=	3.34×10^5 J kg^{-1}
Specific latent heat of vaporization of water		=	2.26×10^6 J kg^{-1}
Avogadro's constant	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan-Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in vacuum	c	=	3.0×10^8 m s^{-1}

1. (a) State Newton's THREE laws of motion.

(i) ______________________________

____

____

(ii) ______________________________

____

____

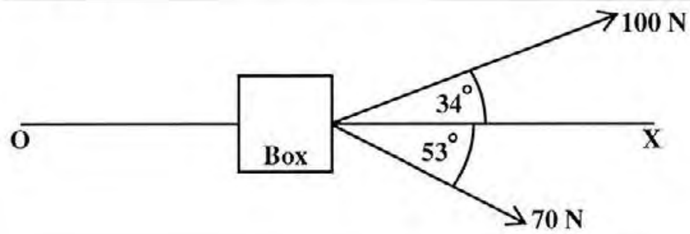
(iii) ______________________________

____

____

[3 marks]

(b) The diagram represents a box with a mass of 80 kg being dragged along a rough surface in the direction **OX**.



(i) Find the component of force the 100 N force in the direction **OX**.

____

[1 mark]

(ii) What is the component of the 70 N force in the direction **OX**?

____

[1 mark]

(iii) The frictional resistance force to the motion is 30 N. What is the acceleration of the box?

[4 marks]

(iv) Explain why there is no motion along the surface in the direction perpendicular to **OX**.

[1 mark]

Total 10 marks

2. (a) Most countries in the Caribbean have a policy of substituting the use of fossil fuels by the use of alternative or non-traditional sources of energy. In your opinion what are the TWO sources MOST likely to be used in your country? Give ONE reason for EACH of your choices.

[4 marks]

(b) Scientists in the Caribbean estimate that the average family uses unnecessarily up to 20% of the energy it pays for. Briefly describe TWO ways, apart from the obvious switching off of equipment not in use, in which some of the wastage could be avoided.

[2 marks]

(c) In the Caribbean on an average day the solar power received is about 300 W for each square metre of land. An engineer proposes to use photovoltaic cells to supply 25 MW of electricity.

The efficiency of the cells is 15%. What area of land would be required for the proposed 25 MW power station?

[4 marks]

Total 10 marks

GO ON TO THE NEXT PAGE

3. A ball is projected vertically upwards and reaches a maximum height in a time of 2.0 s before falling back to the point where it was launched.

(a) On the axes in Figure I sketch graphs of displacement, velocity and acceleration against time for this motion, assuming air resistance is negligible.

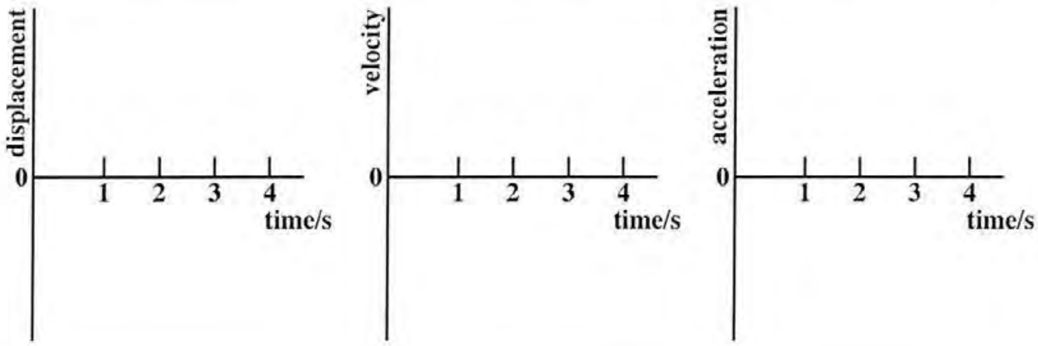


Figure I

[3 marks]

(b) What was the vertical velocity of the ball when it returned to its starting point?

[3 marks]

(c) Find the velocity of the ball after 3 s.

[2 marks]

(d) In practice air resistance may have a significant effect on the ball's motion. Describe how the acceleration of the ball would change during the motion if air resistance is taken into account.

[2 marks]

Total 10 marks

GO ON TO THE NEXT PAGE

4. A student is provided with TWO identical springs which obey Hooke's Law, $F = kx$. (F is the force extending the spring, x is the extension caused and k is a constant.)

(a) The student hangs a mass of 0.40 kg on one of the springs and it extends by 12.5 cm.

(i) Find the value of the force constant k of this spring.

[1 mark]

(ii) The student then pulls down the mass and makes it oscillate. What will be its period?

[3 marks]

(b) The student then repeats the procedure, first using the TWO springs side by side (in parallel) and then with the TWO springs in series as shown in Figure II.

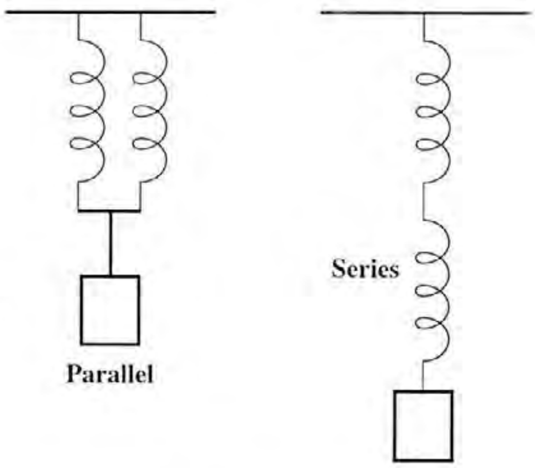


Figure II

Complete the Table 1 below to show the values you would expect her to obtain for the extension (x), period (T) and force constant (k) for the TWO systems. Show any necessary working in the space below the table.

Table 1

	x/cm	k/N m^{-1}	T/S
Parallel			
Series			

[6 marks]

Total 10 marks

5. The diagram in Figure III represents the passage of light through a semi-circular perspex block.

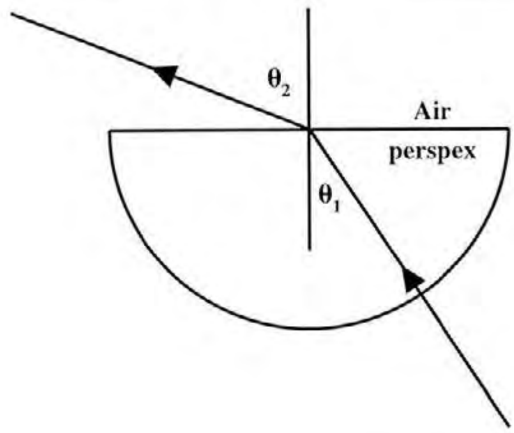


Figure III

(a) (i) Explain why the light is NOT deviated as it passes through the circular surface.

____

____

____

____

[1 mark]

(ii) With reference to the angles marked on the diagram explain what is meant by the term **'critical angle'**.

____

____

____

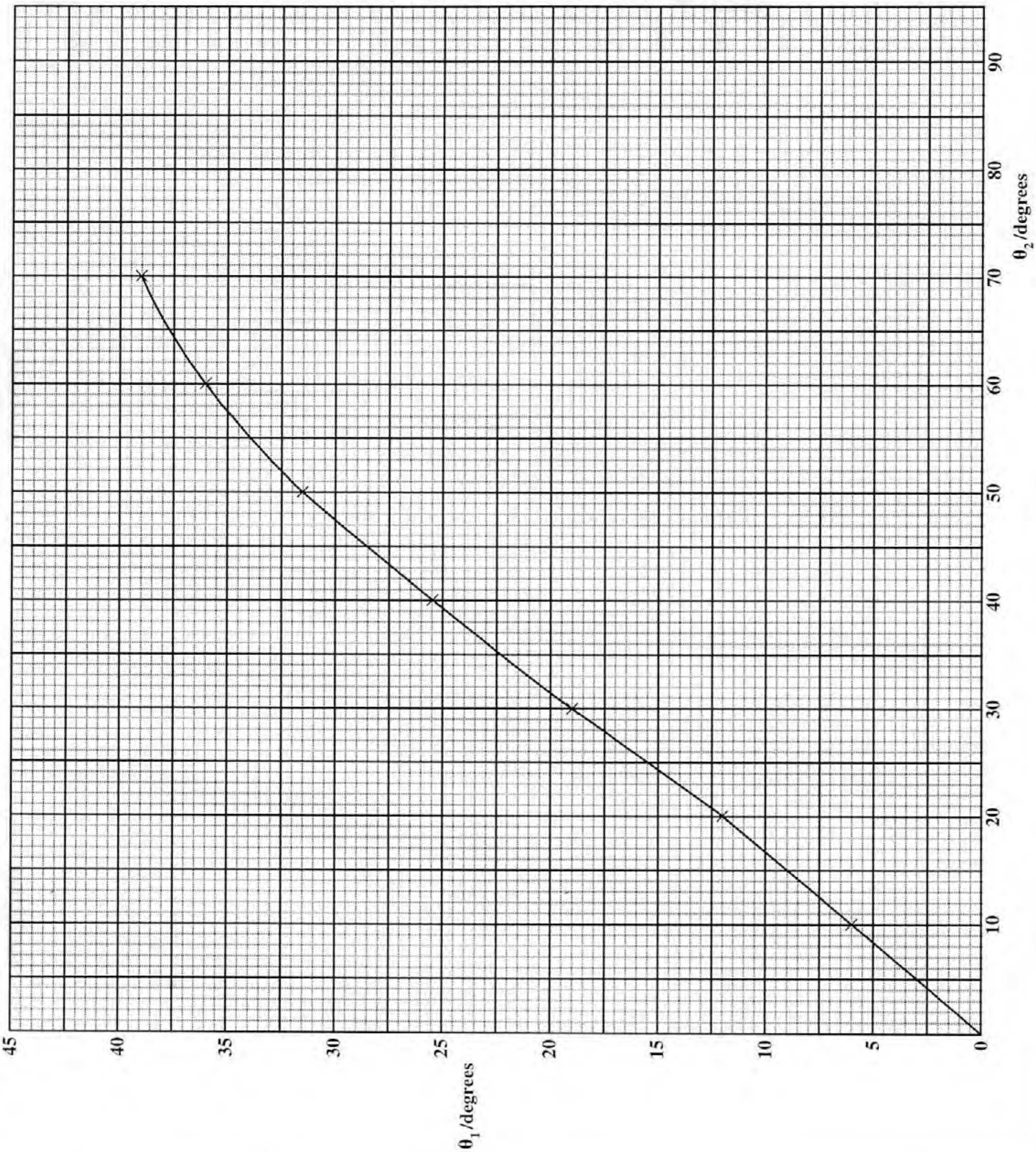
____

____

____

[2 marks]

The following graph refers to question 5 (b)



(b) The graph on page 10 shows how the angle θ_2 varies with the angle of incidence θ_1.

(i) By extrapolating the graph, find the (approximate) value of the critical angle.

____

[1 mark]

(ii) Use the value found in (b) (i) to find the refractive index of the perspex.

____

____

____

[2 marks]

(c) Read off the value of the angle of refraction when the angle of incidence is 45° and use this to find the value for the refractive index of the perspex. **[3 marks]**

(d) Draw rays on Figure III to show what happens when the angle θ_1 equals 60°.

[1 mark]

Total 10 marks

6. A middle-aged man has an eye defect. He cannot focus clearly on objects less than 80 cm from his eyes.

(a) What is the name of this eye defect?

____

[1 mark]

(b) Add a suitable lens to Figure IV and draw rays to show how the defect may be overcome.

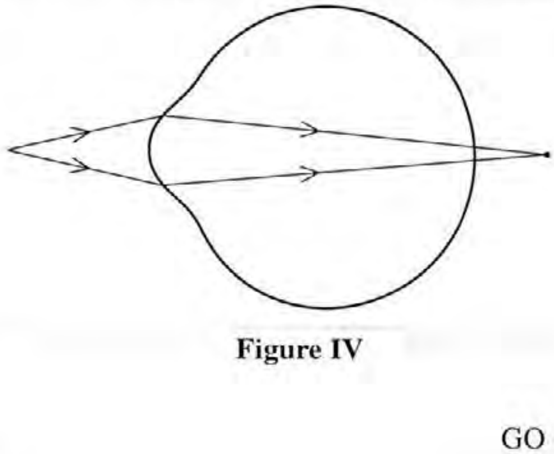


Figure IV

[2 marks]

GO ON TO THE NEXT PAGE

(c) What would be the focal length and power (in diopters) of the lenses needed if the man is enabled to read comfortably a book held 25 cm from his eyes?

[4 marks]

(d) Draw a ray diagram (not to scale) to show where the image in one of the correcting lenses would be formed for an object 80 cm away. Hence explain why the gentleman takes off his glasses when NOT reading.

[3 marks]

Total 10 marks

7. (a) The graph in Figure V shows the extension caused by different loads hung from a uniform wire 2.0 m long and 0.43 mm in diameter.

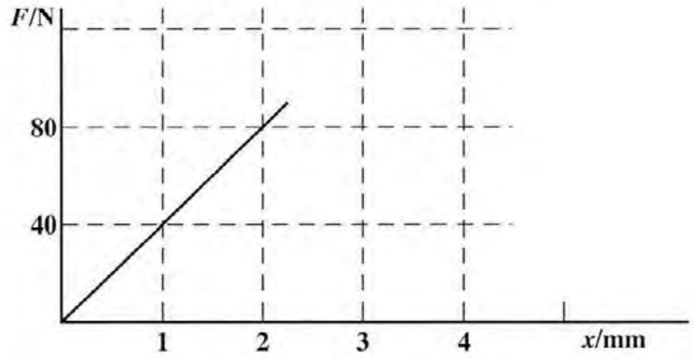


Figure V

(i) Extend the graph to show the effect of loading the wire beyond its elastic limit. **[1 mark]**

(ii) Show on the graph how the work done in stretching it 1.5 mm can be represented. **[1 mark]**

(iii) Calculate the work done in stretching the wire 1.5 mm

[2 marks]

(iv) Find the Young Modulus of the wire under test.

[4 marks]

GO ON TO THE NEXT PAGE

(b) On the axes shown in Figure VI sketch the graphs you would expect to obtain when stretching a strip of rubber or stretching a glass fibre up to their breaking point.

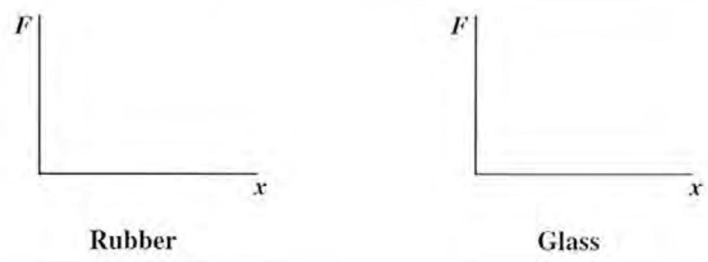


Figure VI

[2 marks]

Total 10 marks

8. (a) In what form is the energy transmitted when heat is transferred by radiation and how does the receiving object get hot?

[2 marks]

(b) Write an equation for Stefan's law of blackbody radiation and explain CAREFULLY the meaning of EACH term.

[3 marks]

(c) A blackened sphere of radius 15 cm and initially at 30°C is suspended inside an oven which is held at a constant temperature of 120°C.

(i) What is the rate of energy absorption by the sphere from the oven?

[2 marks]

(ii) What, initially, is the **net** rate of energy absorption of the sphere?

[2 marks]

(iii) What is the condition for the sphere's temperature to stop rising and remain constant at 120°C?

(Surface area of a sphere = $4\pi r^2$)

[1 mark]

Total 10 marks

9. (a) An ideal gas initially with a volume of 2.0 m^3 at a pressure of 1.0×10^5 Pa is taken through a cycle as described by the graph in Figure VII.

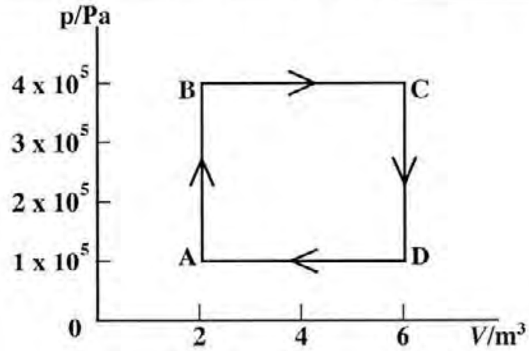


Figure VII

(i) Complete the second column of Table 2 with a brief description of the process occurring in the four parts of the cycle. **[4 marks]**

(ii) In the third column of Table 2 insert the amount of work done ON the gas in EACH stage. **[3 marks]**

Table 2

Section	Description	Work done/J
AB		
BC		
CD		
DE		

(iii) By means of shading show on Figure VII the net work done per cycle for this process. **[1 mark]**

(iv) The 1st law of thermodynamics can be written in the form: $\Delta U = Q + W$
What are the values of ΔU and Q for a whole cycle in Figure VII, starting from A and ending at A.

____

____

____

[2 marks]

Total 10 marks

END OF TEST

TEST CODE **02138020**

FORM TP 2005259

MAY/JUNE 2005

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 01 – Paper 02

2 hours 15 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **NINE** questions.
2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in this answer booklet.
3. Section B consists of **SIX** questions. Candidates must attempt **THREE** questions in this section, **ONE** question from **EACH** Module. Answers for this section must be written in the answer booklet provided.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted.

NOTHING HAS BEEN OMITTED

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
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Stefan-Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in vacuum	c	=	3.0×10^8 m s^{-1}

The following grid refers to question 1.

SECTION A

Attempt ALL questions. You MUST write in this answer booklet. You must NOT spend more than 30 minutes on this section.

1. The following data were collected in a terminal velocity experiment. Small metal spheres were timed over a distance of **80.0 cm** as they fell at constant velocity in thick engine oil.

Table 1

Radius r/mm	Time/s	Velocity v/cm s^{-1}	lg (v/cm s^{-1})	lg (r/ mm)
1.00	44.8			
1.49	20.1			
2.02	11.3			
2.51	7.2			
2.99	5.0			

It is suggested that the terminal velocity v is related to the radius r by the formula

$v = k\,r^{n}$ where k and n are constants.

(a) Complete Table 1 and plot a suitable graph on the grid on page 4 to enable you to find the value of n. (Note that it is NOT necessary to convert the units to metres.)

[7 marks]

(b) Write the equation of the graph you have drawn.

____

[1 mark]

(c) What is the MOST likely value of the constant n?

____

____

____

[2 marks]

Total 10 marks

2. TWO steel pendulum bobs are suspended in such a way that the heavy one drives the lighter one when it oscillates. (See Figure I) The length of the heavy pendulum is fixed at 40.0 cm but the length L of the lighter one can be varied.

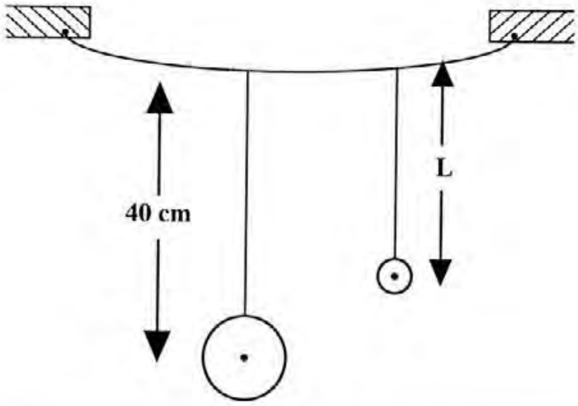


Figure I

The data in Table 2 shows the amplitude of oscillation of the small pendulum for various lengths. The large pendulum bob had a constant amplitude of 5.0 cm each time.

Table 2

L/cm	amplitude/cm
32.0	1.7
34.0	2.0
36.0	2.7
38.0	4.5
40.0	11.0
42.0	8.0
44.0	4.0
46.0	2.5
39.0	9.0
41.0	10.0

(a) On the grid provided on page 6, plot a graph to show how the amplitude of the driven pendulum varies with its length. **[5 marks]**

(b) The last TWO readings in Table 2 seem to be extra readings. Why did the experimenter consider it necessary to go back and take these extra readings?

____

____

[1 mark]

(c) Calculate the period and frequency of the heavy pendulum.

[3 marks]

(d) What is the resonant frequency of the light pendulum?

[1 mark]

Total 10 marks

3. The following instruments were used in an electrical method to determine the specific heat capacity of a metal using the equation $VIt = mc\,\Delta\theta$. The metal sample was in the form of a cylinder with holes drilled for a heater and a thermometer.

Moving coil voltmeter	0 – 10 V	smallest division 0.2 V
Moving coil ammeter	0 – 5 A	smallest division 0.1 A
Stop clock		smallest division 0.01 s.
Balance	0 – 1000 g	smallest division 10 g
Mercury thermometer		smallest division 1°C

(a) Complete Table 3 to show the estimated uncertainty (random error) in EACH measurement.

Table 3

Quantity	**Value**	**Uncertainty**
mass, m	930 g	±
initial temp θ_1	28.0°C	±
final temp θ_2	51.8°C	±
p.d., V	9.8 V	±
current, I	4.3 A	±
time, t	500 s	negligible

[4 marks]

(b) Calculate the value of the specific heat capacity given by this experiment TOGETHER with the uncertainty in the value.

[4 marks]

(c) Suggest TWO ways in which the systematic error in this experiment could be reduced.

____

____

____

____

[2 marks]

Total 10 marks

SECTION B

You must attempt THREE questions from this section. Choose ONE question EACH from Module 1, 2 and 3. You MUST write your answers in the answer booklet provided.

MODULE 1

Answer EITHER Question 4 OR Question 5.

4. (a) Figures II (a) and II (b) show an apparatus known as Newton's cradle, consisting of 5 identical spheres hung from a frame. It is used to demonstrate elastic collisions.

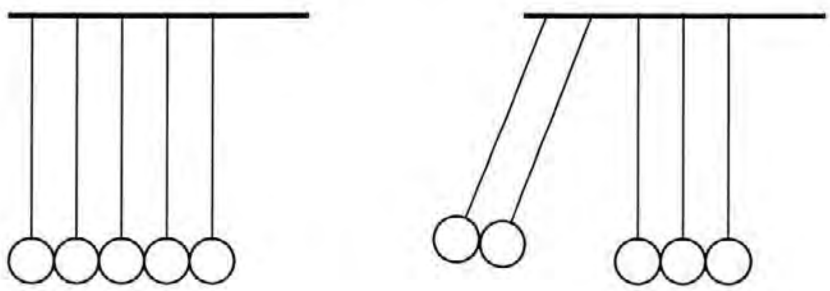


Figure II (a) **Figure II (b)**

(i) Define the term '*momentum.*'

(ii) Which TWO physical quantities are conserved in an elastic collision?

(iii) TWO of the spheres, each of mass m, are pulled to one side as shown in Figure II (b) and released so that they strike the others with velocity v. A student observing the demonstration predicts that immediately after the collision ONE sphere will move off from the other side with velocity $2v$ while the first TWO spheres come to rest.

Show that this is NOT possible since only one of the two quantities in (a) (ii) is conserved.

(iv) In fact in the above demonstration the incoming spheres come to rest but TWO spheres move off together on the other side with velocity v. Show that BOTH the conservation laws are now satisfied.

[8 marks]

(b) In a crash test a car of mass 1200 kg hits a wall and recoils. The initial velocity of the car is 20 m s^{-1} and it bounces back at 1.5 m s^{-1} as shown in Figure III. The contact with the wall lasts for 0.18 s.

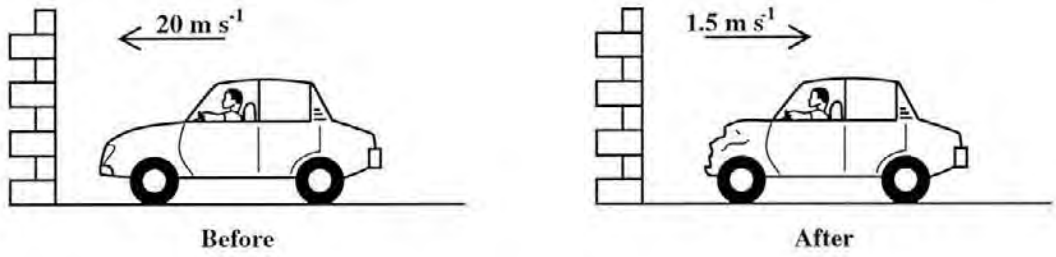


Figure III

(i) What is the change of momentum of the car during this collision?

(ii) Find the impulse of the force acting on the car.

(iii) Sketch a graph to show the typical variation of force with time during a collision like this and state what the area under the graph represents.

(iv) Find the average force acting on the car during the collision.

(v) Discuss why modern cars are designed to crumple in a head-on collision. Illustrate your answer with a sketch graph (labelled CRASH 2) using the same scale as in part (b) (iii) to show how the force varies with time when a car crumples more than the one in the diagram.

[12 marks]

Total 20 marks

5. (a) (i) Explain using Newton's laws how the propeller of a light aeroplane like the one shown in Figure IV is able to provide forward thrust.

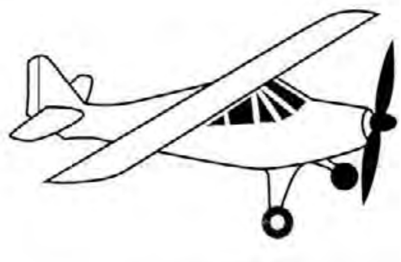


Figure IV

(ii) The forward thrust caused by the propeller of an aeroplane is 18 000 N and the air flowing through it leaves with a velocity of 250 m s^{-1}. What mass of air must pass through the propeller EACH second? **[5 marks]**

GO ON TO THE NEXT PAGE

(b) In order to turn, an aeroplane must "bank" as shown in Figure V, so that the lift force is no longer vertical. (Assume that the aeroplane remains in level flight and travels at constant speed.)

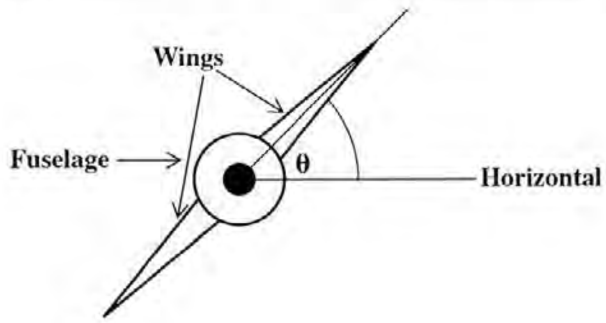


Figure V

(i) Draw a diagram like the one in Figure V with arrows to show the direction of the external forces acting on the aeroplane as it turns. On a second, similar diagram show the direction of the RESULTANT force acting on the plane.

(ii) Calculate the radius of the circular path for a plane of mass 3 000 kg with a horizontal speed of 120 km per hour if the resultant force acting is 16 000 N.

(iii) Find the size of the lift force on the plane and the banking angle θ.

(iv) Each passenger on the light aeroplane must also experience a resultant unbalanced force to move in a circular path. With the aid of a diagram state how this force is provided.

[15 marks]

Total 20 marks

MODULE 2

Answer EITHER Question 6 OR Question 7.

6. (a) Explain the physical principles of the production of spectra by diffraction gratings. Include in your account an explanation of how the zero order, first order and second order spectra are produced. **[5 marks]**

(b) (i) A source emits a mixture of monochromatic red and monochromatic yellow light. Draw a ray diagram to show the production of the zero, first and second order spectra of this light from this source by a diffraction grating.

(ii) The diffraction grating produces a second order spectrum for the red light of wavelength 630 nm at an angle of 43.9° from the normal to the grating. What is the spacing of the lines in the grating? How many lines per millimetre does the grating have?

(iii) Find the angle of deviation from the normal for the first order red light and first order yellow light of wavelength 570 nm.

(iv) Show that the yellow light produces a 3rd order spectrum but the red light can only produce two orders with this grating. **[15 marks]**

Total 20 marks

GO ON TO THE NEXT PAGE

7. (a) (i) Derive the formula $y = \lambda D/a$ for interference of light waves from a double slit where y is the spacing of the fringes on a screen at a distance D from a double slit with spacing a and λ is the wavelength of the monochromatic light producing the interference pattern.

(ii) Explain why the formula gives only an approximate value. **[8 marks]**

(b) TWO loudspeakers connected in parallel to a signal generator are used to demonstrate the interference of sound waves in an experiment analogous to that for light. Figure VI illustrates the experiment set up.

As a microphone is moved along the line YX it detects a maximum of sound intensity at O and then another maximum at X.

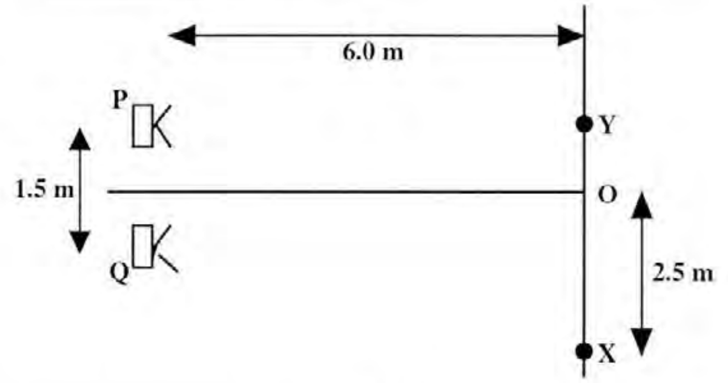


Figure VI

(i) Find the distances PX and QX from the speakers to the first maximum at X and hence find the wavelength of the sound waves.

(ii) What value does the formula $y = \lambda D/a$ give for the wavelength of the sound waves?

(iii) Discuss the fact that the values given in (b) (i) and (ii) are different.

(iv) What is the frequency of the sound from the speakers?

(v) The phase of speaker P is changed by 180°. What effect will this have on the sound heard at points O and X ?

Data:
[Velocity of sound in air = 330 ms^{-1}]

[12 marks]

Total 20 marks

MODULE 3

Answer EITHER Question 8 OR Question 9.

8. (a) (i) Write the formula for linear heat flow by conduction explaining EACH of the terms in the equation carefully.

(ii) When measuring the thermal conductivity of a sample of metal in the form of a cylinder it is usual for the cylinder to be about 20 cm long with a diameter of about 3 cm. Outline THREE reasons why these dimensions are suitable.

(iii) What is the MAIN potential source of error in an experiment like this and how is it overcome?

[8 marks]

(b) A home-made cooler is constructed from plywood and foam plastic. The walls consist of two pieces of plywood 1.0 cm thick with a 1 cm layer of foam plastic in between. When in use the temperature inside the box is 2 °C while the outside temperature is 30 °C.

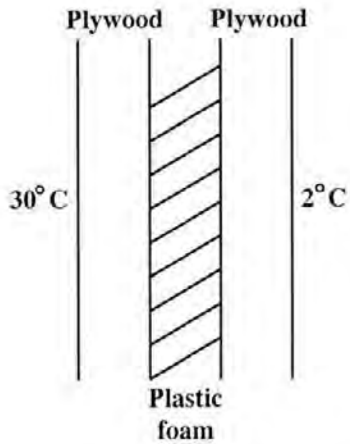


Figure VII

(i) Sketch a graph to show how the temperature varies across the wall of the box.

(ii) The thermal conductivity of plywood is 0.24 W m^{-1} K^{-1} whilst that of the plastic foam is 0.012 W m^{-1} K^{-1}. Calculate the thickness of a piece of plywood which would have the same insulating effect as 1 cm of foam.

(iii) Using this equivalent thickness, or otherwise, find the rate of conduction of heat through a rectangular wall of the box which is 0.6 m by 0.4 m and deduce the temperatures at the two interfaces between plywood and plastic foam.

[12 marks]

Total 20 marks

GO ON TO THE NEXT PAGE

9. (a) (i) Explain why the molecules of a gas do not all move at the same speed.

(ii) What is the meaning of the term *r.m.s. speed*? How is it calculated?

(iii) Derive the expression relating the *r.m.s. speed* of the molecules of an ideal gas to the pressure exerted by the gas:

$$pV = \frac{1}{3} Nm\,\overline{c^2}$$

[8 marks]

(b) A volume of 0.14 m^3 of helium (molar mass 4 g/mol) at a temperature of 400 K has a pressure of 1.6×10^5 Pa.

(i) What is the mass of the helium?

(ii) Find the *r.m.s. speed* of the helium molecules.

(iii) What would be the *r.m.s. speed* of oxygen molecules (molar mass 32 g/mol) at the same temperature of 400 K?

[12 marks]

Total 20 marks

END OF TEST

TEST CODE **02238010**

FORM TP 2005260

MAY/JUNE 2005

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 02 – Paper 01

1 hour 45 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **NINE** questions. Candidates must attempt **ALL** questions.
2. Candidates **MUST** write in this answer booklet and all working **MUST** be **CLEARLY** shown.
3. The use of non-programmable calculators is permitted.

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
Elementary charge	e	=	1.60×10^{-19} C
The Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration of free fall	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

1. (a) (i) Explain what is meant the 'drift velocity' of charge carriers.

[1 mark]

(ii) Figure I shows a current i flowing through a length of wire L, with cross sectional area A. There are n charge carriers per unit volume present. The average drift velocity of the charge carriers is v_d and the charge on each charge carrier is q.

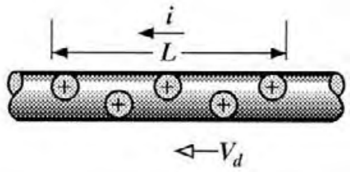


Figure I

Show that the drift velocity, v_d, of the charge carriers is given by $v_d = \dfrac{I}{nqA}$.

[4 marks]

(b) In Figure II, current of 0.10 A flows through a copper wire 0.10×10^{-3} m in diameter and then through a salt solution contained in a glass tube 0.010 m in diameter. The density of conduction electrons in copper is 1.1×10^{29} m^{-3}. The current in the solution is carried equally by positive and negative ions with charges $2e$ and the number of each ion species per unit volume is 6.1×10^{23} m^{-3}.

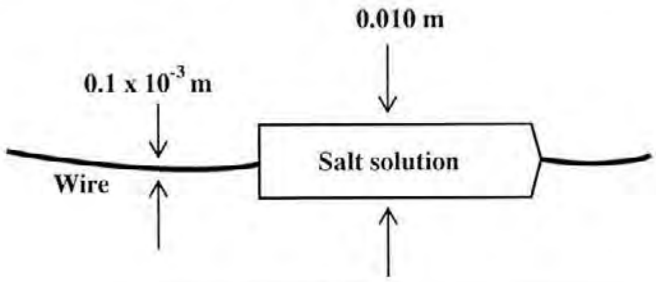


Figure II

(i) Calculate the number of electrons passing through the wire EACH second.

[2 marks]

(ii) Calculate the drift velocity of the charge carriers in the salt solution.

[3 marks]

Total 10 marks

GO ON TO THE NEXT PAGE

2. (a) Figure III shows a point charge Q at A. B is a point a distance r from Q.

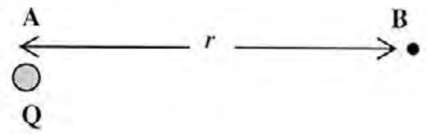


Figure III

(i) Write an expression for

a) the electric field at B

____

[1 mark]

b) the electric potential at B.

____

[1 mark]

(ii) Show how the electric field and electric potential of B are related.

____

[1 mark]

(b) Figure IV shows a small light-conducting sphere supported by a long fine vertical nylon thread, suspended between TWO large metal plates. The plates are connected to a high voltage d.c. supply.

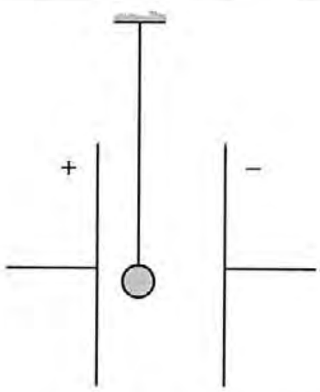


Figure IV

(i) Explain why the uncharged sphere is attracted to the positive plate.

____

[1 mark]

(ii) Explain why the sphere subsequently oscillates between the plates.

[3 marks]

(iii) When the ball is not touching either plate, the force on the ball is 0.05 N. The plates are 10 cm apart and the supply voltage is set to 1 kV.

Calculate the charge on the sphere.

[3 marks]

Total 10 marks

3. (a) State

(i) Faraday's law of electromagnetic induction

[1 mark]

(ii) Lenz's Law.

[1 mark]

(b) Giving an example, explain how Lenz's law can be considered as an application of the law of conservation of energy.

[2 marks]

(c) A flat coil of wire consists of 500 circular loops of radius 2.0 cm. It is placed between the poles of a large electromagnet so that the plane of the coil is perpendicular to a uniform magnetic field of 0.15 T.

(i) Calculate the magnetic flux through each turn of the coil.

[2 marks]

(ii) If the electromagnet is turned off and it takes 0.20 s for the field to go down to zero, what would be the e.m.f. induced in the coil of wire?

[2 marks]

GO ON TO THE NEXT PAGE

(iii) State TWO reasons why transformers are NOT usually 100 per cent efficient.

[2 marks]

Total 10 marks

4. (a) State THREE properties of the ideal operational amplifier (op - amp).

[3 marks]

(b) Figure V shows an op - amp being used as a comparator. The open loop gain of the amplifier is 2×10^5.

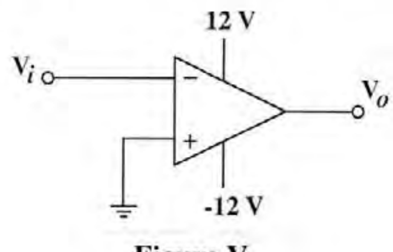


Figure V

(i) Calculate the positive and negative input voltages at which saturation will be reached.

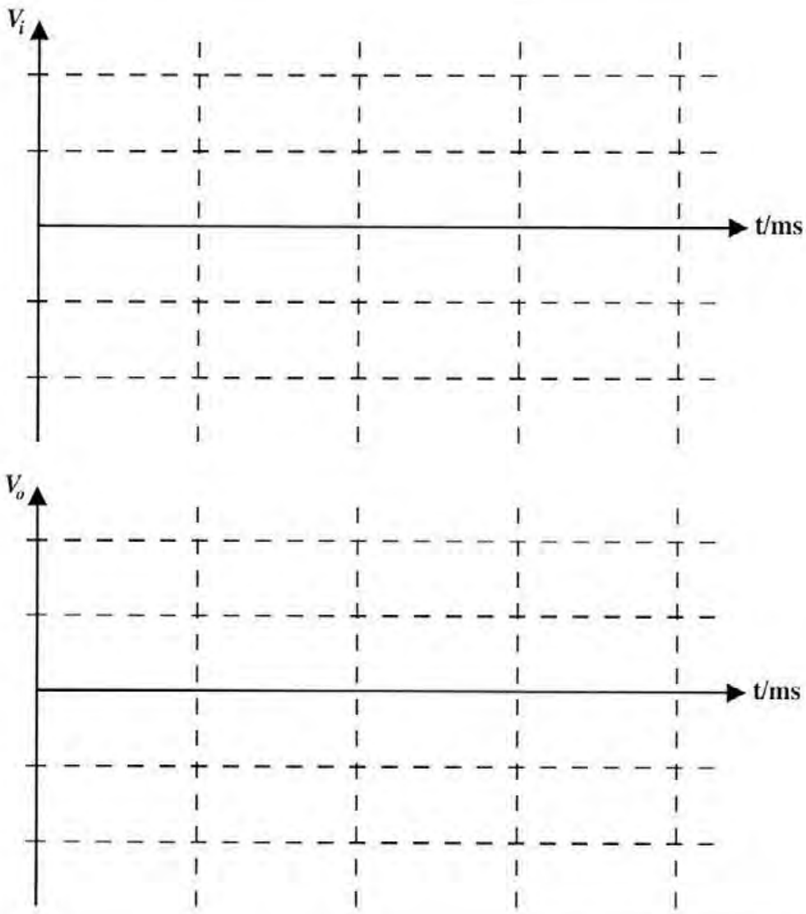
[2 marks]

GO ON TO THE NEXT PAGE

(ii) A signal with voltage V_i given by $V_i = 0.2 \sin(100\pi t)$ is applied to the comparator in (b) (i). Calculate the frequency of the signal.

[1 mark]

(iii) On the axes below sketch both the input voltage V_i and the output voltage V_o for TWO complete cycles CLEARLY indicating the maximum voltages and periodic times on the axes.



[4 marks]

Total 10 marks

GO ON TO THE NEXT PAGE

5. (a) Figure VI shows the pn junction of a silicon diode connected to a power supply. Initially, the switch is in the open position as shown.

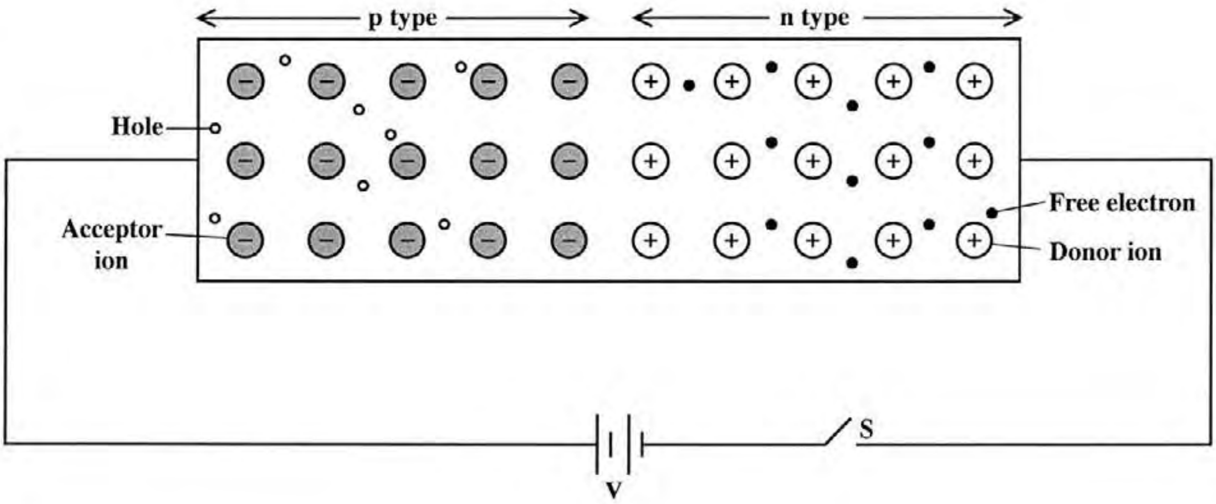


Figure VI

(i) Sketch the I-V characteristic curve for such a diode.

[2 marks]

(ii) Explain what is meant by the depletion layer at a pn junction and indicate this layer on Figure VI.

____

____

____

[1 mark]

(iii) Indicate the following on Figure VI:

a) The direction of the diffusion current. Label this arrow with an X.

b) The direction of the drift current. Label this arrow with a Y.

[2 marks]

(iv) The switch in Figure VI is now closed. Describe how the depletion layer is affected and explain the effect.

____

____

____

____

[2 marks]

(b) Consider the circuits shown in Figure VII in which each circuit is connected to an a.c. supply and has a cathode ray oscilloscope (c.r.o.) across its output. For each circuit in Figure VII, (ii)-(iv), sketch the output voltage as seen on the cathode ray oscilloscope on the axes beside the circuit diagram.

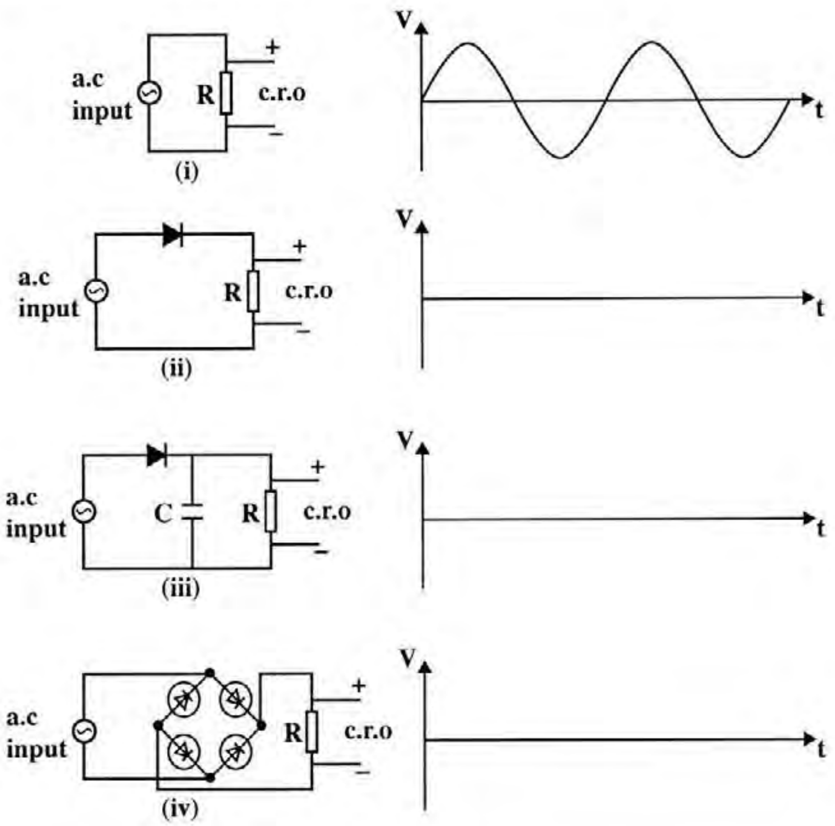


Figure VII

[3 marks]

Total 10 marks

GO ON TO THE NEXT PAGE

6. (a) (i) List TWO general areas in which digital electronics is commonly employed.

____

____

[2 marks]

(ii) Write down the truth table for the EXCLUSIVE-OR (X-OR) gate.

[1 mark]

(iii) Explain how an X-OR gate can be used to detect when TWO binary digits are different?

____

____

____

[1 mark]

(b) Figure VIII shows a digital circuit with inputs A and B.

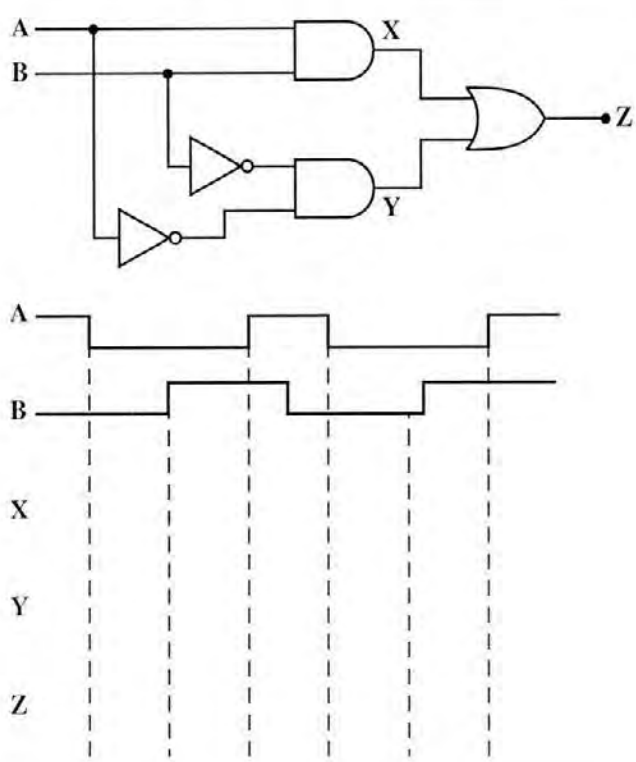


Figure VIII

(i) Complete the truth table below to show the outputs at Y and Z.

A	B	X	Y	Z
0	0	0		
0	1	0		
1	0	0		
1	1	1		

[2 marks]

(ii) Sketch, in the space provided in Figure VIII, the output waveform at X, Y and Z if the input waveforms A and B are as indicated. **[3 marks]**

(iii) What single logic gate is equivalent to the circuit in Figure VIII?

____

____

[1 mark]

Total 10 marks

GO ON TO THE NEXT PAGE

7. Figure IX shows an apparatus for the production of X-rays, using molybdenum as the target metal. Molybdenum's innermost (K-shell) electrons have an energy of 20 keV whilst the outermost (M-shell) electrons have an energy level of 200 eV.

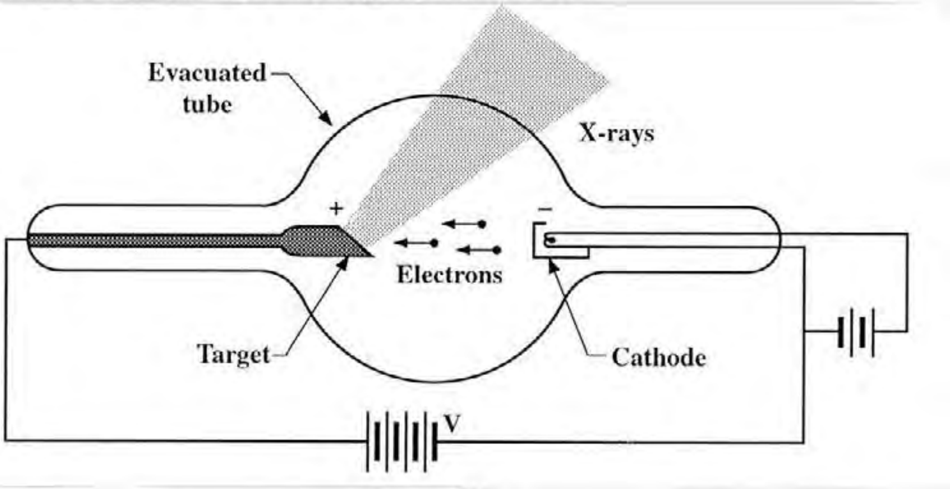
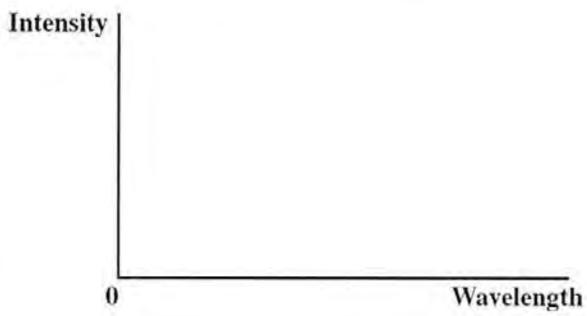


Figure IX

(a) Sketch the typical Intensity-wavelength X-ray spectrum for molybdenum, CLEARLY indicating the minimum continuous X-ray wavelength, λ_{min}, and the characteristic peaks in the intensity.



[3 marks]

(b) Explain the origin of the characteristic peaks observed in your sketch in (a).

____

____

____

____

____

____

[2 marks]

(c) One of the K-shell electrons is removed from the atom by electron bambardment and its vacancy is filled by an M-shell electron.

Calculate the wavelength of the emitted X-rays.

[3 marks]

(d) The tube is operated from a 25 kV supply. What is the minimum wavelength of the continuous spectrum of X-rays?

[2 marks]

Total 10 marks

8. (a) Explain what is meant by the following terms when referring to a radioactive source.

(i) Half-life

____

____

[1 mark]

(ii) Decay constant

____

____

[1 mark]

(b) The half-life of a radioactive sample of Radium, ${}^{226}_{88}Ra$, is 1.6 x 10^3 years.

(i) Calculate the decay constant of ${}^{226}_{88}Ra$.

[3 marks]

(ii) The sample contains 5.0 x 10^{16} such nuclei at $t = 0$. Calculate its activity at this time.

[2 marks]

GO ON TO THE NEXT PAGE

(iii) Calculate the decay rate when the sample is 2.5×10^3 years old.

[Data: 1 year = 3.2×10^7s]

[3 marks]

Total 10 marks

9. (a) Figure X shows a section of a Geiger-Muller tube.

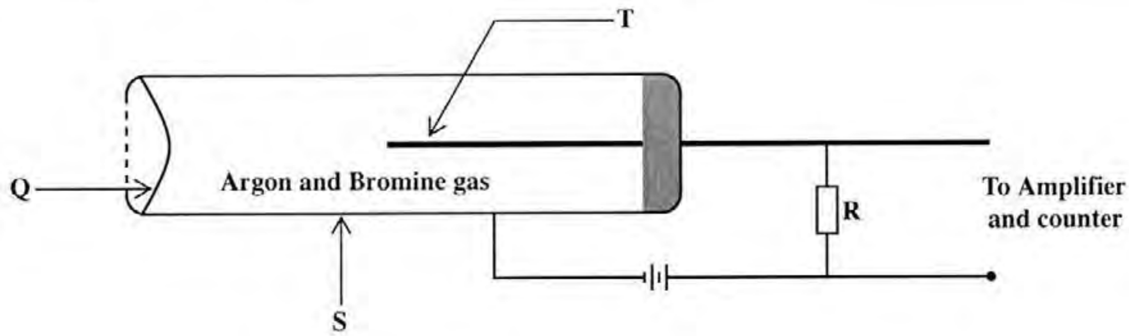


Figure X

(i) Beside EACH letter write the name of the parts labelled Q, S and T in Figure X.

Q ______________________________

S ______________________________

T ______________________________

[3 marks]

(ii) Describe the principle of the operation of a G - M tube.

____

____

____

[1 mark]

GO ON TO THE NEXT PAGE

(iii) Explain why a mixture of argon and bromine gas is used in the tube.

[2 marks]

(b) A radioactive source is known to emit α , β and γ radiation. The source is placed in a magnetic field as shown in Figure XI. The field is directed into the page. A Geiger-Muller tube moves from position A to position B.

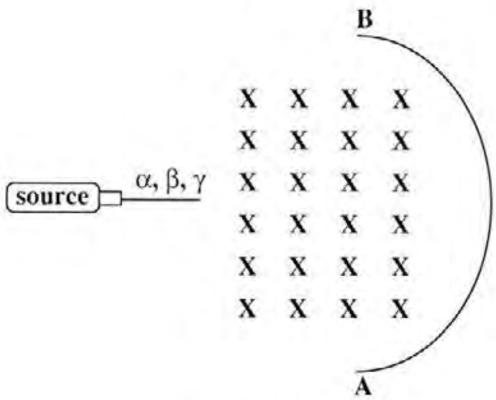


Figure XI

(i) Identify the type of radiation recorded at position A.

Position A

[1 mark]

(ii) Show on Figure XI the region where γ radiation would be detected.

[1 mark]

(iii) If the distance from the source to the Geiger-Muller tube is about 15 cm α -particles cannot be detected. Explain why.

____

____

[2 marks]

Total 10 marks

END OF TEST

TEST CODE **02238020**

FORM TP 2005261

MAY/JUNE 2005

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 02 – Paper 02

2 hours 15 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **NINE** questions.
2. Section A consists of **THREE** questions. Candidates must attempt ALL questions in this section. Answers for this section must be written in this answer booklet.
3. Section B consists of **SIX** questions. Candidates must attempt **THREE** questions in this section, **ONE** question from **EACH** Module. Answers for this section must be written in the answer booklet provided.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted.

NOTHING HAS BEEN OMITTED

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
Elementary charge	e	=	1.60×10^{-19} C
The Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration of free fall	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Attempt ALL questions. You MUST write in this answer booklet. You must NOT spend more than 30 minutes on this section.

1. Figure I shows TWO flat circular coils with n turns, each of radius R, and separated by a disance a. Each coil carries a current I in the same direction.

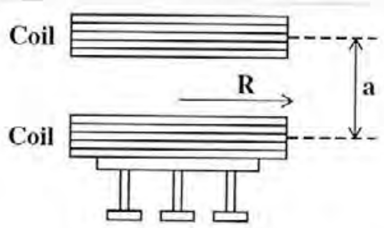


Figure I

The force of attraction between the TWO coils is given by $F = \dfrac{\mu_o n^2 I^2 R}{a}$ where μ_o is the permeability of free space.

In an experiment it is desired to measure the value of the permeability of free space, μ_o, by using the setup shown in Figure II. Initially, weights were added to the scale pan to suspend the coil. These weights were kept on during the experiment. The separation of the coils, a, was set to 1 cm. Each coil has n = 100 turns with radius R = 5.0 cm. The current through the coils was varied and weights were added to the scale pan to balance the scale.

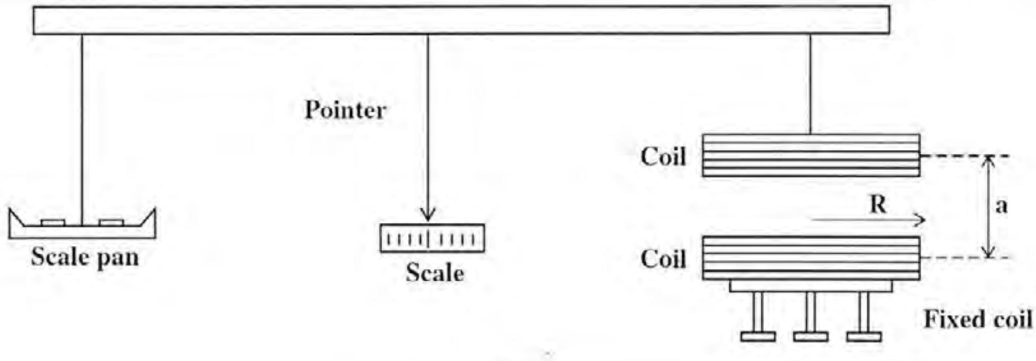
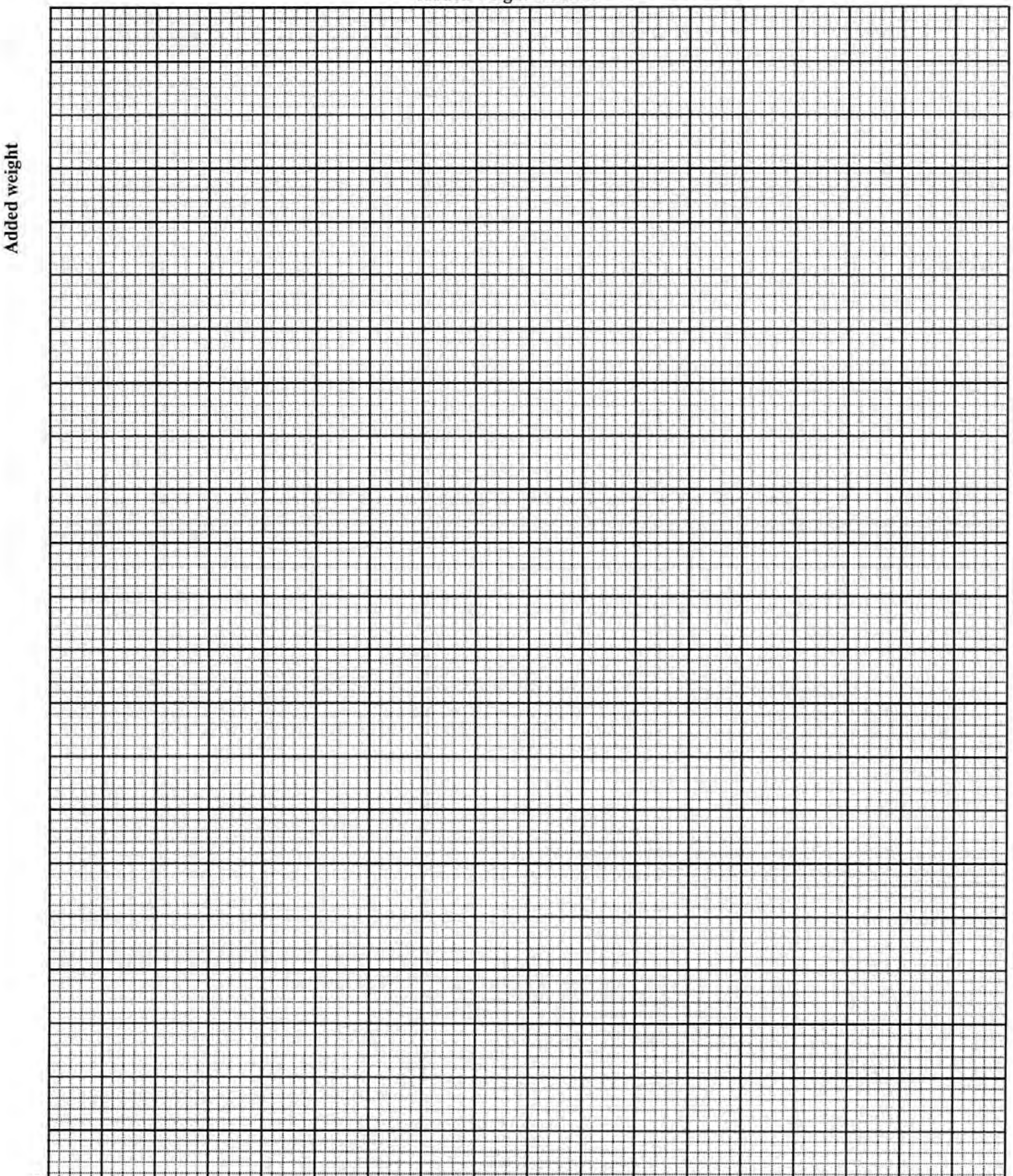


Figure II

The following grid refers to question 1.

Added weight versus I^2



The following results were obtained.

Table 1

Added Weight, F, / N x 10^{-2}	**Current, I, / A x 10^{-2}**	**I^2 / A^2 x 10^{-4}**
1.0	4.0	
2.0	5.6	
3.0	6.9	
4.0	8.0	
5.0	8.9	

(a) Complete the third column of Table 1 **[1 mark]**

(b) On the grid provided on page 5 plot a graph of Added Weight, F, versus I^2. **[5 marks]**

(c) Use your graph to determine a value for the permeability of free space, μ_o.

[4 marks]

Total 10 marks

2. The variation of the gain of an inverting amplifier at different frequencies may be investigated with the circuit shown in Figure III. The input and output signals are displayed on the screen of a double beam cathode ray oscilloscope. The input signal is provided by a signal generator.

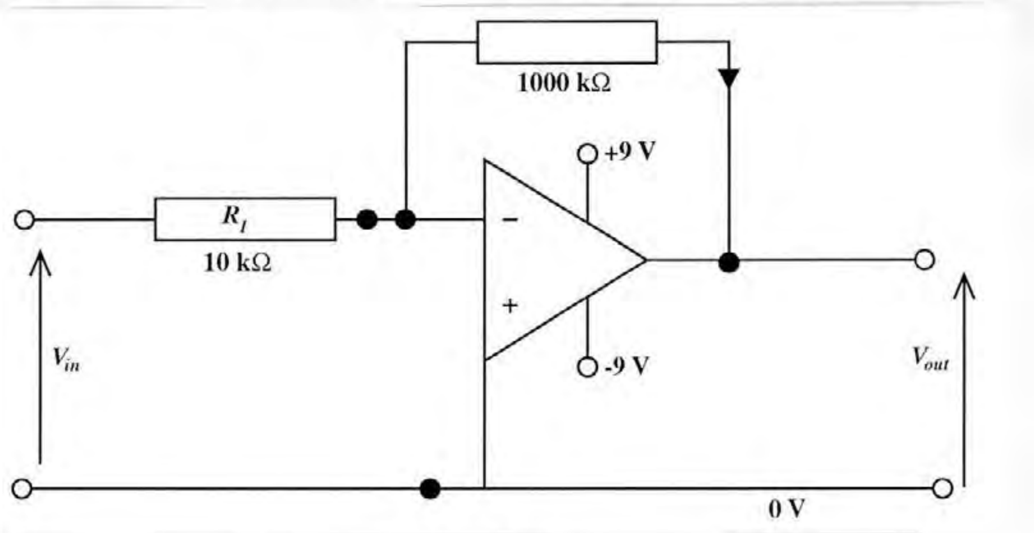


Figure III

(a) What is the gain of this amplifier at low frequencies?

____

____

[1 mark]

(b) At higher frequencies the gain may be lower than this theoretical value. It can be measured by use of the double beam oscilloscope. Figure IV below shows the output trace and the input trace at a higher frequency.

The gain setting of the c.r.o. for the output is 1V per division whilst that for the input trace is 10 mV per division.

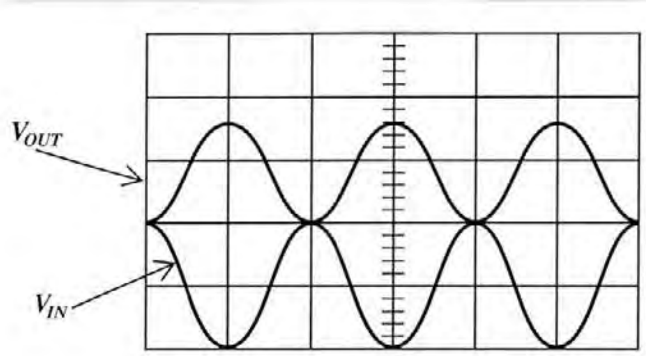
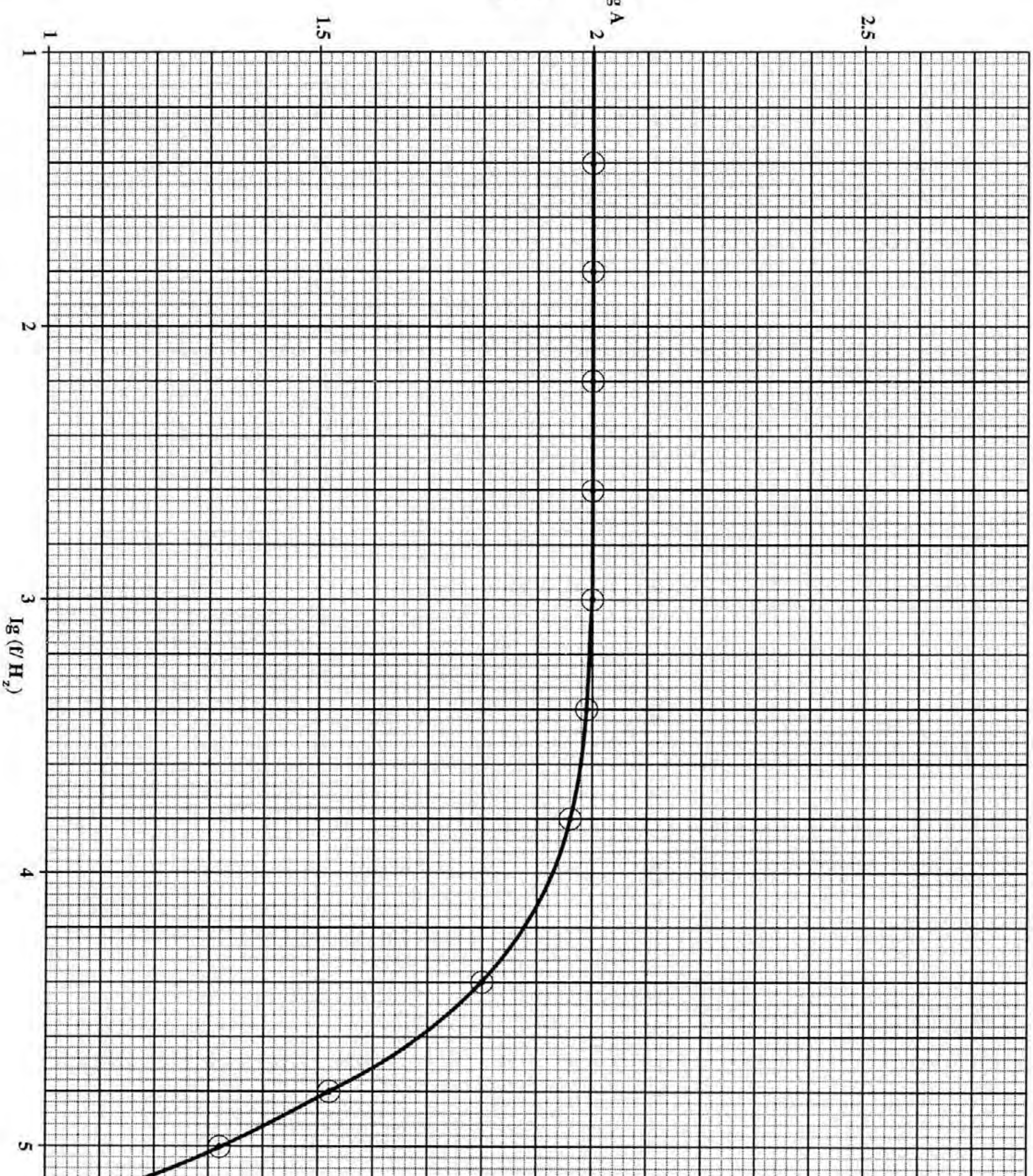


Figure IV


lg A
1
1.5
2
2.5
1
2
3
4
5
lg (f/ H_z)

What is the gain, A, of the amplifier for this frequency?

[3 marks]

(c) The graph on page 8 shows the data collected in such an experiment. Use the graph to complete Table 2.

Table 2

lg(f/Hz)	lg A	f/HZ	A
2.00			
3.00			
4.00			
4.50			
5.00			

[3 marks]

(d) (i) What is the bandwidth of the amplifier?

[1 mark]

(ii) The value of the input resistance R_1 is changed to 1.0 kΩ. How will the low frequency gain and bandwidth of the amplifier change?

[2 marks]

Total 10 marks

3. In an experiment to determine the half life of a radioactive sample, the following data was obtained over a 10 hour period. The activity, A and time, t are related by the equation $A = A_o e^{-\lambda t}$

Table 3

Time/min	**Activity (counts/min)**	
60	3100	
120	2450	
240	1480	
360	910	
480	545	
600	330	

(a) After adding suitable data to the third column of Table 3, (there is no need to convert the minutes to seconds) plot a straight line graph on the grid on page 11.

State the equation of the line you plotted. **[6 marks]**

(b) Use the graph you plotted to determine the half-life of the sample.

[4 marks]

Total 10 marks

GO ON TO THE NEXT PAGE

SECTION B

You must attempt THREE questions from this section. Choose ONE question EACH from Module 1, 2 and 3. You MUST write your answers in the answer booklet provided.

MODULE 1

Answer EITHER Question 4 OR Question 5.

4. (a) (i) Explain CLEARLY the difference between 'e.m.f.' and 'terminal potential difference'.

(ii) Define the 'volt' and the 'coulomb'.

(iii) Write down Kirchhoff's laws for electrical networks and give the physical basis for EACH law.

[8 marks]

(b) In the circuit shown in Figure V, batteries A and B have negligible internal resistance. Battery C has an internal resistance of 3 Ω .

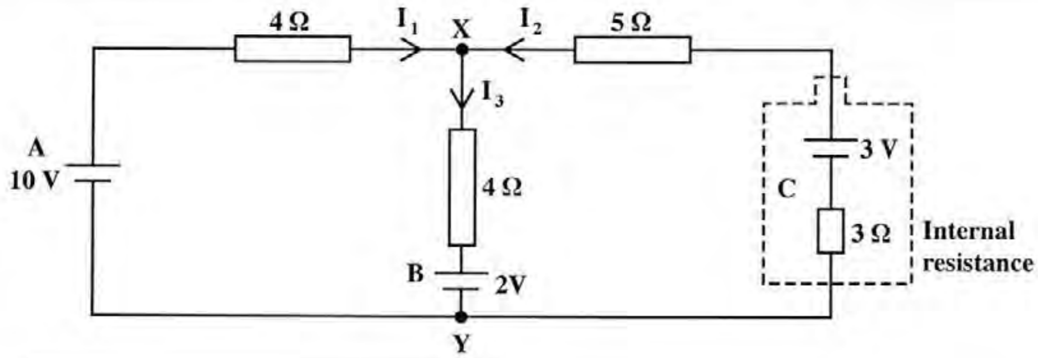


Figure V

Use the circuit in Figure V to find

(i) the currents I_1, I_2 and I_3

(ii) the potential difference between X and Y

(iii) the terminal p.d. of Battery C.

[12 marks]

Total 20 marks

5. (a) Explain the origin of the Hall effect. Include a diagram showing clearly the directions of the Hall voltage and other relevant quantities for a specimen in which electron conduction predominates. **[8 marks]**

(b) A Hall probe can be used to measure the magnitude of a magnetic field. A researcher has lost his instruction booklet and forgotten the calibration procedure. However, when he places the Hall probe inside a known magnetic field of 15 mT, he measures a Hall voltage of 130 mV. With the same Hall probe, he measures a Hall voltage of 1170 mV when it is placed in an unknown magnetic field.

Using this information, calculate the magnetic field strength of the unknown magnetic field. **[2 marks]**

(c) In the velocity selector of a mass spectrometer positive ions travelling at 1.6×10^5 m s^{-1} pass undeflected through a magnetic field of 0.15 T which is perpendicular to an electric field.

(i) Draw a labelled diagram to show the relationship between the two fields.

(ii) Write equations for the forces on the ions caused by the electric field and the magnetic field and hence calculate the field strength E of the electric field. **[5 marks]**

(d) Figure VI shows a metal strip 6.50 cm long, 0.850 cm wide which moves with constant velocity v through a uniform magnetic field B = 1.20 mT. The magnetic field is directed perpendicularly to the strip. A potential difference of 3.90 μV is measured between points C and D across the strip. Calculate the velocity, v, of the strip.

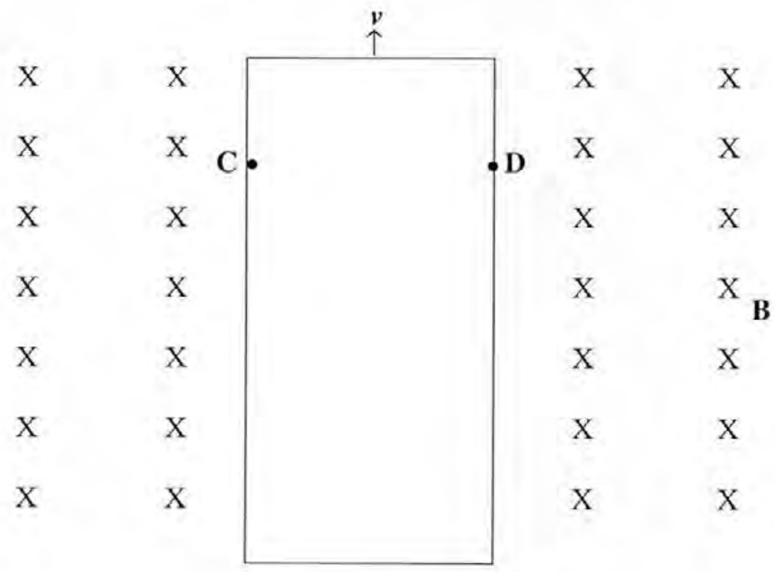


Figure VI

[5 marks]

Total 20 marks

GO ON TO THE NEXT PAGE

MODULE 2

Answer EITHER Question 6 or Question 7.

6. (a) Draw a labelled diagram of a transformer suitable for transforming from 240 V a.c to 12 V a.c. Give details of the materials used in its structure and reasons for their choice.

[8 marks]

(b) A step up transformer connected to a 240-V r.m.s a.c line is to supply 18 kV r.m.s. for a neon sign as shown in Figure VII. To reduce shock hazard, a fuse is to be inserted in the primary circuit; the fuse is to blow when the current in the secondary circuit exceeds 10 mA.

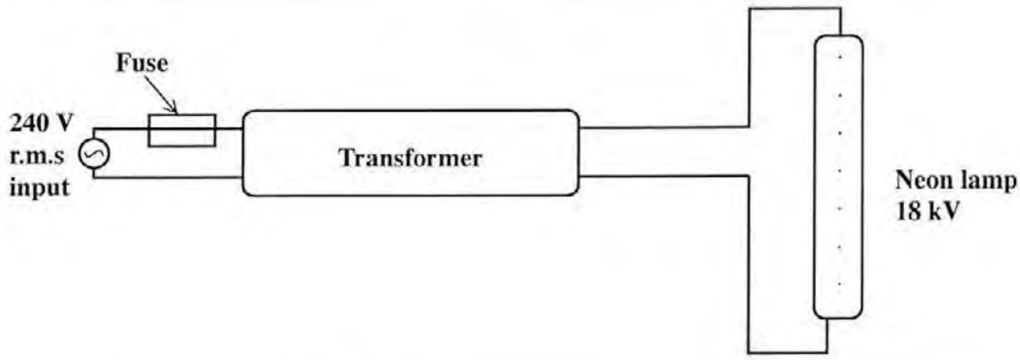


Figure VII

Calculate, assuming the transformer is ideal,

(i) the peak value of the primary voltage

(ii) the turns ratio $\frac{N_p}{N_s}$ of the transformer

(iii) the power that must be supplied to the transformer when the secondary current is 10 mA

(iv) the current rating of the fuse that is to be used in the primary circuit.

[8 marks]

(c) The transformer at a power station has an output of 15 MW at 60 kV. This power is transmitted to a sub-station some distance away along cables which have a total resistance of 12 Ω. What percentage of the power transmitted is lost in the cables?

[4 marks]

Total 20 marks

7. (a) Figure VIII shows a logic circuit with TWO inputs, I_1 and I_2, and TWO outputs X and Y.

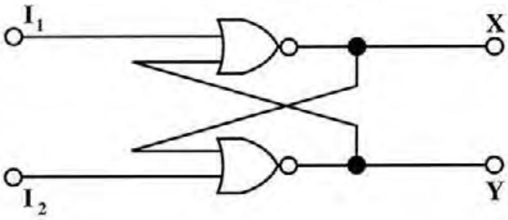


Figure VIII

(i) What is the name given to this type of circuit?

(ii) Name the logic gate used in the circuit and write out its truth table.

(iii) Copy and complete the sequential truth table to show the action of the circuit in Figure VIII.

Table 4

sequence	I_1	I_2	**X**	**Y**
1	0	1	1	0
2	0	0	1	0
3	1	0		
4	0	0		
5	0	1		
6	0	0		

(iv) By considering the role of feedback in this circuit and the condition for the type of gate in (a) (ii) to have a logic *0* output, explain why the output does not change when the input changes in the second step of the sequence (Row 2) as shown in Table 4.

[8 marks]

(b) The circuit of Figure VIII is incorporated in a burglar alarm as shown in Figure IX.

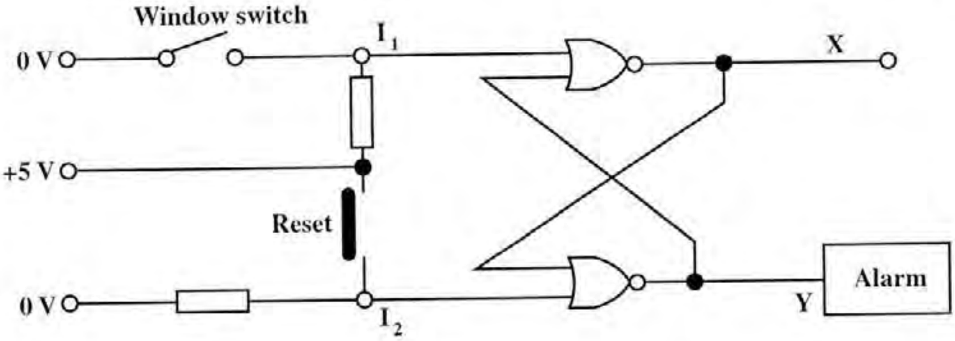


Figure IX

When the window is shut the switch is closed and I_1 is logic 0. When the window is opened I_1 = 1.

The input I_2 remains at logic 0 except when the reset switch is pressed.

(i) Before going to bed the householder closes the window and presses and releases the reset switch. Making reference to the sequential truth table in 7(a) (iii), explain how this "sets" the alarm so that it is ready to be triggered.

(ii) Why does the alarm sound when a burglar opens the window?

(iii) Explain why the alarm stays on even when the burglar closes the window.

(iv) How does the householder turn off the alarm? **[4 marks]**

(c) (i) Draw the circuit for a half-adder. Explain, with the aid of a truth table, what its function is and how it performs that function.

(ii) TWO half-adders can be connected to form a full-adder, Figure X. This circuit has THREE inputs.

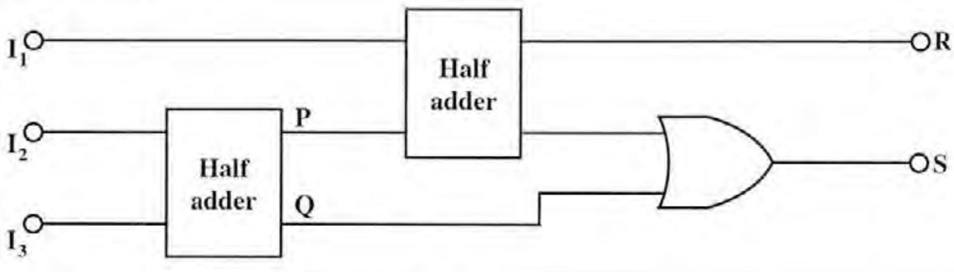


Figure X

Draw a table to show the outputs at points P, Q, R and S for the following input states:

A. $I_1 = 1$ $I_2 = 0$ $I_3 = 1$

B. $I_1 = 1$ $I_2 = 1$ $I_3 = 1$

[8 marks]

Total 20 marks

GO ON TO THE NEXT PAGE

MODULE 3

Answer EITHER Question 8 or Question 9.

8. (a) (i) Define the terms, 'work function', 'threshold frequency' and 'stopping potential' as applied in describing the photoelectric effect.

(ii) What property of light does the photoelectric effect display? **[4 marks]**

(b) In a photoelectric experiment the intensity of blue light incident on a metal surface is varied. Figure XI shows a plot of photocurrent versus applied voltage for different values of light intensity.

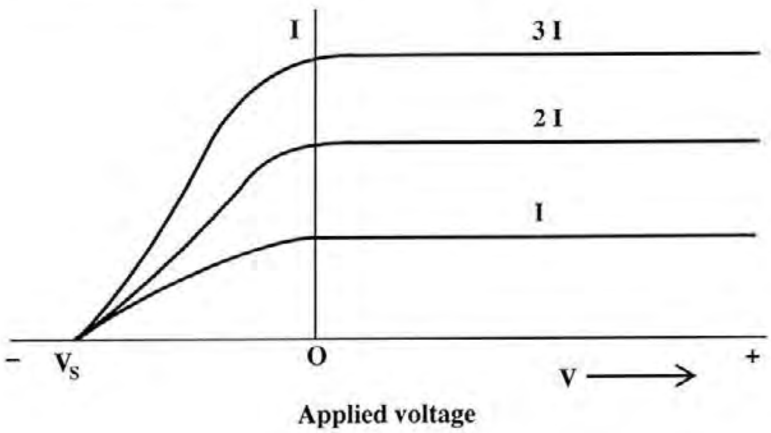


Figure XI

(i) What conclusions can be drawn from this plot?

(ii) Explain how the maximum kinetic energy and maximum velocity of the photoelectrons can be deduced from this plot.

[4 marks]

(c) Light of intensity 1.5×10^{-2} Wm^{-2} and wavelength 250×10^{-9} m is incident on an iron surface of area 1×10^{-4} m^2. The iron surface reflects 95% of the light. The threshold frequency for iron is 1.1×10^{15} Hz.

Calculate

(i) the intensity of light available for the photoelectric effect

(ii) the number of electrons emitted per second

(iii) the work function in electron volts for iron

(iv) the stopping potential for this radiation.

[12 marks]

Total 20 marks

9. (a) (i) Explain what is meant by 'nuclear fusion' and 'nuclear fission' and state which process is responsible for the energy release of the Sun.

(ii) Explain why a neutron would penetrate farther into a sample of matter than an alpha particle of the same energy.

(iii) The graph in Figure XII shows the binding energy per nucleon versus mass number (A) curve.

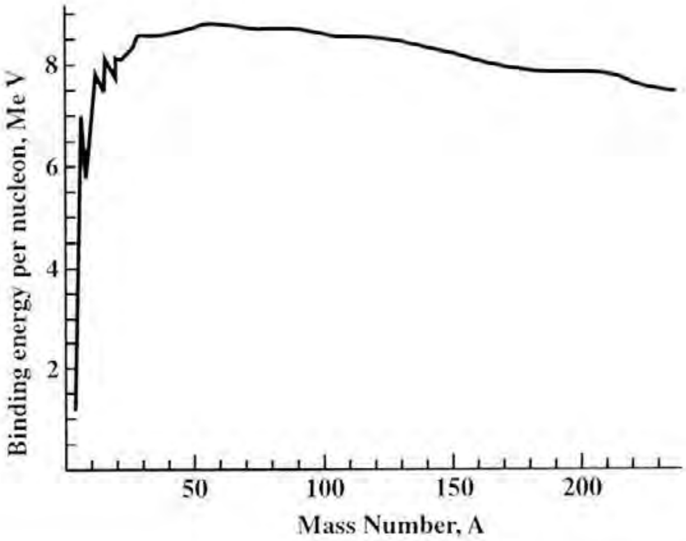


Figure XII

What does this curve indicate about the stability of nuclei and the processes by which nuclei achieve this stability? **[8 marks]**

(b) The fission of Uranium-235 can be represented by the nuclear equation

$$^{235}_{92}U \rightarrow {}^{140}_{54}Ce + {}^{94}_{38}Zr + {}^{1}_{0}n.$$

Atomic Masses:

$^{235}_{92}U$	235.0439 u	$^{140}_{54}Ce$	139.9054 u	[1 u ≡ 931.5 MeV]
$^{1}_{0}n$	1.00867 u	$^{94}_{38}Zr$	93.9063 u	

(i) How many atoms are contained in 1.0 kg of Uranium-235?

(ii) Using the masses above, calculate the energy, in joules, released by 1.0 kg of Uranium-235 by fission.

(iii) Using your answer to (ii) above, explain why nuclear fission is such a desirable source of energy. **[12 marks]**

Total 20 marks

END OF TEST

TEST CODE **02138010**

FORM TP 2006263

MAY/JUNE 2006

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 01 – Paper 01

1 hour 45 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **NINE** questions. Candidates must attempt **ALL** questions.
2. Candidates **MUST** write in this answer booklet and all working **MUST** be **CLEARLY** shown.
3. The use of non-programmable calculators is permitted.

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
Acceleration due to gravity	g	=	9.80 m s^{-2}
Radius of the Earth	R_E	=	6380 km
Mass of the Earth	M_E	=	5.98×10^{24} kg
Mass of the Moon	M_M	=	7.35×10^{22} kg
1 Atmosphere	Atm	=	1.00×10^5 N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water		=	1.00×10^3 kg m^{-3}
Thermal conductivity of copper		=	400 W m^{-1} K^{-1}
Specific heat capacity of aluminium		=	910 J kg^{-1} K^{-1}
Specific heat capacity of copper		=	387 J kg^{-1} K^{-1}
Specific heat capacity of water		=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice		=	3.34×10^5 J kg^{-1}
Specific latent heat of vaporization of water		=	2.26×10^6 J kg^{-1}
Avogadro's constant	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan-Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in vacuum	c	=	3.0×10^8 m s^{-1}

1. (a) State the difference between vector and scalar quantities and give TWO examples of each.

[3 marks]

(b) (i) Using the information shown in Figure 1, complete the table to show the components of the vectors P and Q and the components of P - Q.

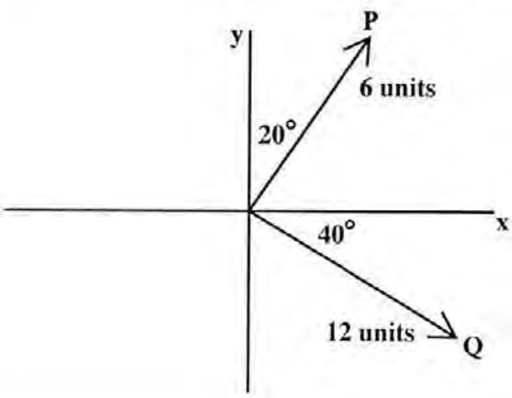
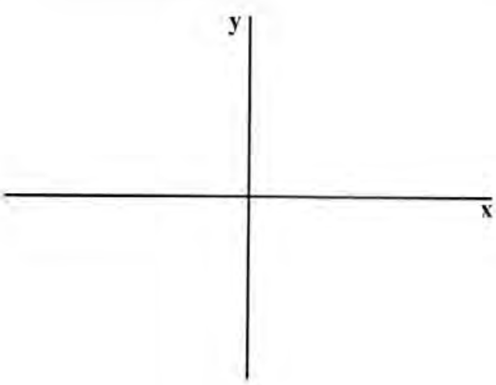


Figure 1

vector	**x component**	**y component**
P		
Q		
P - Q		

[4 marks]

(ii) On the axes below draw a labelled vector through the origin representing the vector P - Q. (Show your calculations in the space next to the diagram).



[3 marks]

Total 10 marks

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2. (a) The graphs in Figure 2 below show how the displacement x and velocity v of an object undergoing uniformly accelerated motion change with time. Under the graphs write the relevant equation and also state what the gradient of each graph represents.

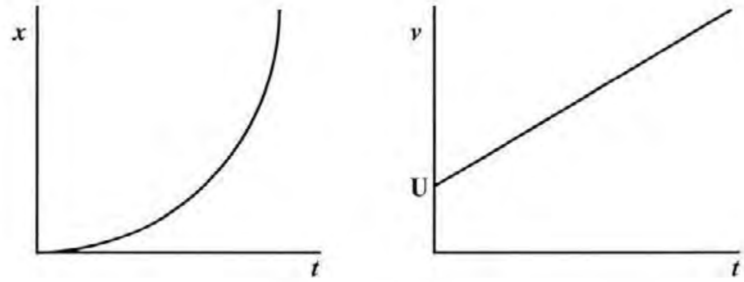

Figure 2

Equation ____________________ ____________________

Gradient represents ____________________ ____________________

[4 marks]

(b) (i) A ball is rolled off a cliff with an initial horizontal velocity of 5 m s^{-1}. Derive an equation for the ball's trajectory (i.e. the relation between its vertical displacement y and its horizontal displacement, x). Use $\mathbf{g = 10\ m\ s^{-2}}$ in this question.

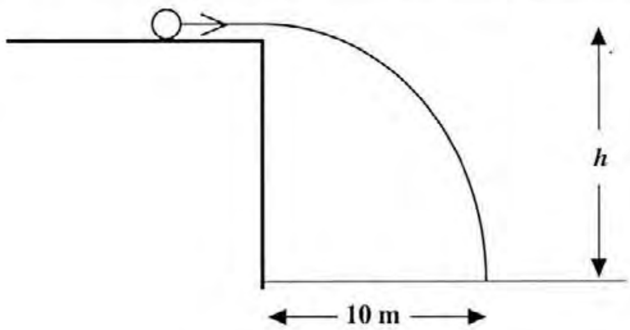

Figure 3

[4 marks]

(ii) Find the height h of the cliff.

[2 marks]

Total 10 marks

3. (a) (i) State Newton's law of gravitation.

[1 mark]

(ii) Explain why an astronaut in a satellite orbiting the Earth may be described as weightless.

[2 marks]

(b) T.V. signals are broadcast in the Caribbean by means of satellites in geostationary orbits.

(i) Explain the meaning of the term 'geostationary orbit'.

[2 marks]

(ii) What is the angular velocity (in radians per second) of a geostationary orbit?

[2 marks]

(iii) Calculate the radius of the orbit of a geostationary satellite.

[3 marks]

Total 10 marks

4. A microwave transmitter is set up behind three vertical aluminium sheets in order to investigate double-slit interference as shown in Figure 4. A receiver is moved around a circular path 1 m from the centre of the slits and the maxima and minima of intensity closest to O are observed at points marked Q and P respectively. The effective slit spacing is 8.0 cm.

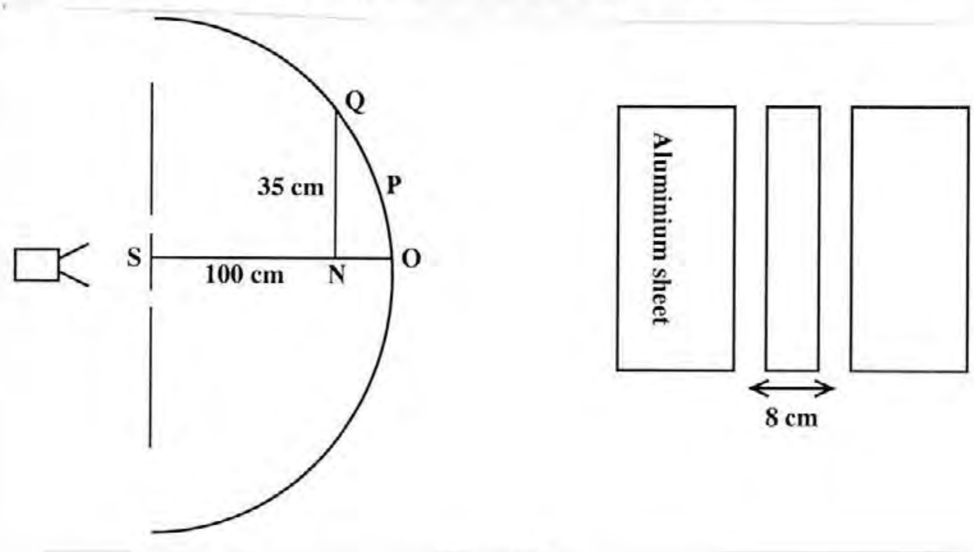

Figure 4

(a) (i) The perpendicular distance from SO to Q is 35 cm. What is the wavelength of the radiation?

[3 marks]

(ii) Explain the formation of a minimum at P.

____

____

____

[2 marks]

(iii) Calculate the value of the angle OSP.

[3 marks]

(b) If a block of transparent material with a higher refractive index than air covers one of the slits the interference pattern moves and the "zeroth" maximum is no longer at O. Explain this.

____

____

____

[2 marks]

Total 10 marks

5. (a) Define the refractive index of a material in terms of the speed of waves in that material.

____

____

[1 mark]

(b) Light is incident at the boundary between two transparent media with refractive indices n_1 and n_2 respectively.

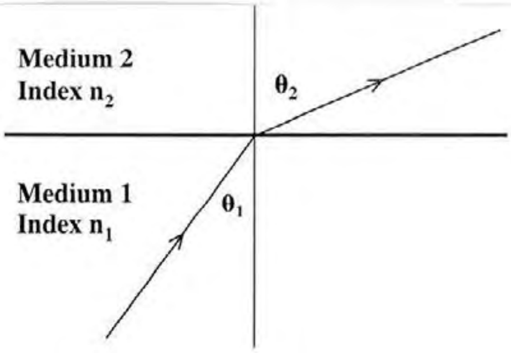

Figure 5

(i) Draw lines on the diagram to represent the wavefronts of the incident and refracted waves.

(ii) In which material do the waves travel faster? ______________________

(iii) Write an equation relating the refractive indices to the angles θ_1 and θ_2 .

[4 marks]

(c) A fibre optic cable consists of a glass core with refractive index 1.49 and glass cladding with refractive index 1.45 as shown in Figure 6.

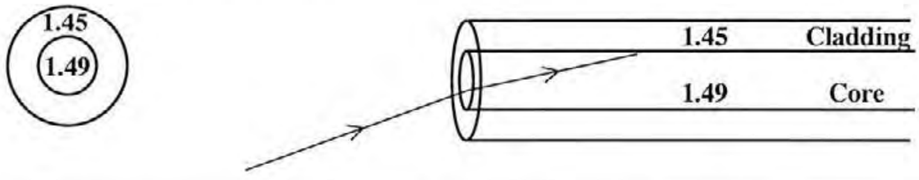

Figure 6

(i) Explain how light is able to travel down the core of the fibre.

____

____

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[1 mark]

(ii) Calculate the minimum angle of incidence for a ray of light incident on the boundary between the core and the cladding if it is to travel down the fibre.

[3 marks]

(iii) If the cable is bent into a tight curve the light does not emerge at the other end. Explain this.

____

____

____

____

[1 mark]

Total 10 marks

GO ON TO THE NEXT PAGE

6. One end of an elastic string is connected to a wall and the other to a vibrator with a frequency of 60 Hz as shown in Figure 7. Standing waves are formed with four loops in the 3.0 m between the vibrator and the wall.

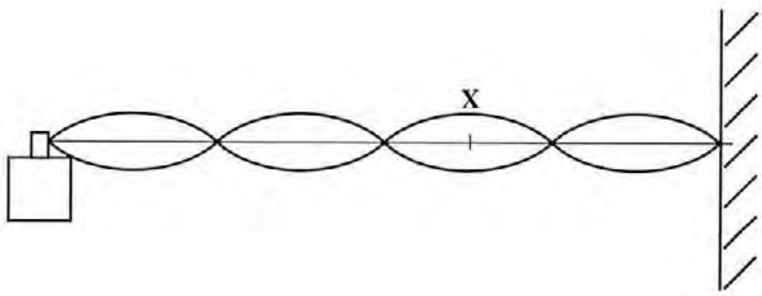


Figure 7

(a) Find the wavelength and velocity of the waves on the string.

Wavelength

Velocity

[3 marks]

GO ON TO THE NEXT PAGE

(b) Point X on the string is vibrating up and down with a frequency of 60 Hz. The amplitude of the motion is 4.0 cm.

(i) Sketch a graph to show how its displacement, y, varies with time, t.

[1 mark]

(ii) Calculate the angular velocity, ω, for this vertical motion.

[1 mark]

(iii) Write an equation, using the values given, for the motion of X.

$$y/\text{cm} =$$

[2 marks]

(iv) Find the maximum acceleration of the point X.

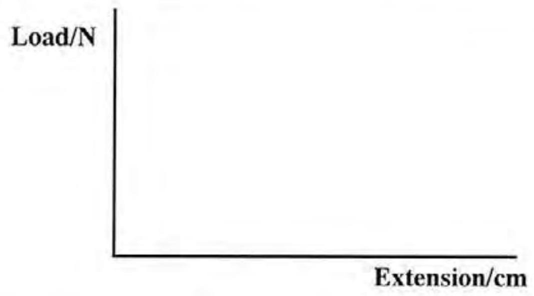
[3 marks]

Total 10 marks

GO ON TO THE NEXT PAGE

7. When a load of 50 N is hung from a spring, it extends by 9.3 cm and the elastic limit is not exceeded.

(a) Sketch on the axes below a graph of load versus extension for this spring.



[1 mark]

(b) Find the spring constant for this spring.

[3 marks]

(c) Calculate the strain energy stored in the spring when a load of 30 N is hung from it.

[4 marks]

(d) When the 30 N load is hung on the spring it loses gravitational potential energy. Explain why this loss of potential energy is NOT equal to the strain energy in the spring.

____

____

____

[2 marks]

Total 10 marks

GO ON TO THE NEXT PAGE

8. (a) 200 g of water at 26 °C are placed in the freezing compartment of a refrigerator. After some time the temperature of the ice formed is found to be –16 °C. Sketch a graph on the axes below to show the variation of temperature with time.

[3 marks]

(b) (i) The freezer extracts heat at an average rate of 80 J s^{-1}. How long does it take for the temperature to go down to 0 °C?

[3 marks]

(ii) How long does it take to freeze the water after the temperature has reached 0 °C?

[3 marks]

(c) What changes in internal energy take place during the freezing process?

[1 mark]

Total 10 marks

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9. (a) Discuss why the following materials are used in the construction of a solar panel for a domestic hot water supply, as shown in Figure 8.

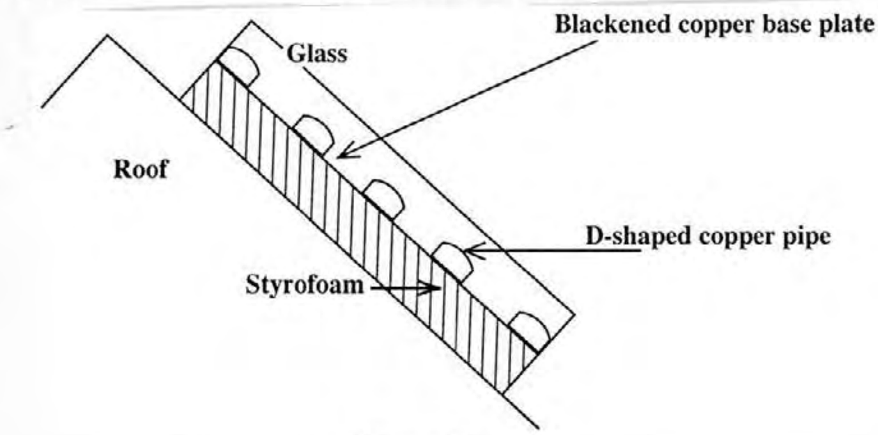

Figure 8

(i) Copper pipes and collector plate

(ii) Black paint

(iii) A glass cover

(iv) Styrofoam

[5 marks]

(b) In the Caribbean most solar water heaters do not have a pump to circulate the water. Describe how the water circulates in these systems with no pump.

[2 marks]

(c) A solar panel receives radiation with an average intensity of 800 W m^{-2} and it is 60% efficient in transferring this energy to the water. What area of panel would be needed for it to be equivalent to a 900 W heater? **[3 marks]**

Total 10 marks

END OF TEST

TEST CODE **02138020**

FORM TP 2006264

MAY/JUNE 2006

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 01 – Paper 02

2 hours 15 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **NINE** questions.
2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in this answer booklet.
3. Section B consists of **SIX** questions. Candidates must attempt **THREE** questions in this section, **ONE** question from **EACH** Module. Answers for this section must be written in the separate answer booklet provided.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted.

NOTHING HAS BEEN OMITTED

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Specific heat capacity of aluminium		=	910 J kg^{-1} K^{-1}
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Specific heat capacity of water		=	4200 J kg^{-1} K^{-1}
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Stefan-Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in vacuum	c	=	3.0×10^{8} m s^{-1}

SECTION A

Attempt ALL questions. You MUST write in this answer booklet.

1. The data in Table 1 below were collected at a laboratory which investigates damage to cars in collisions. In this case a car with a mass of 1200 kg was driven into a solid wall.

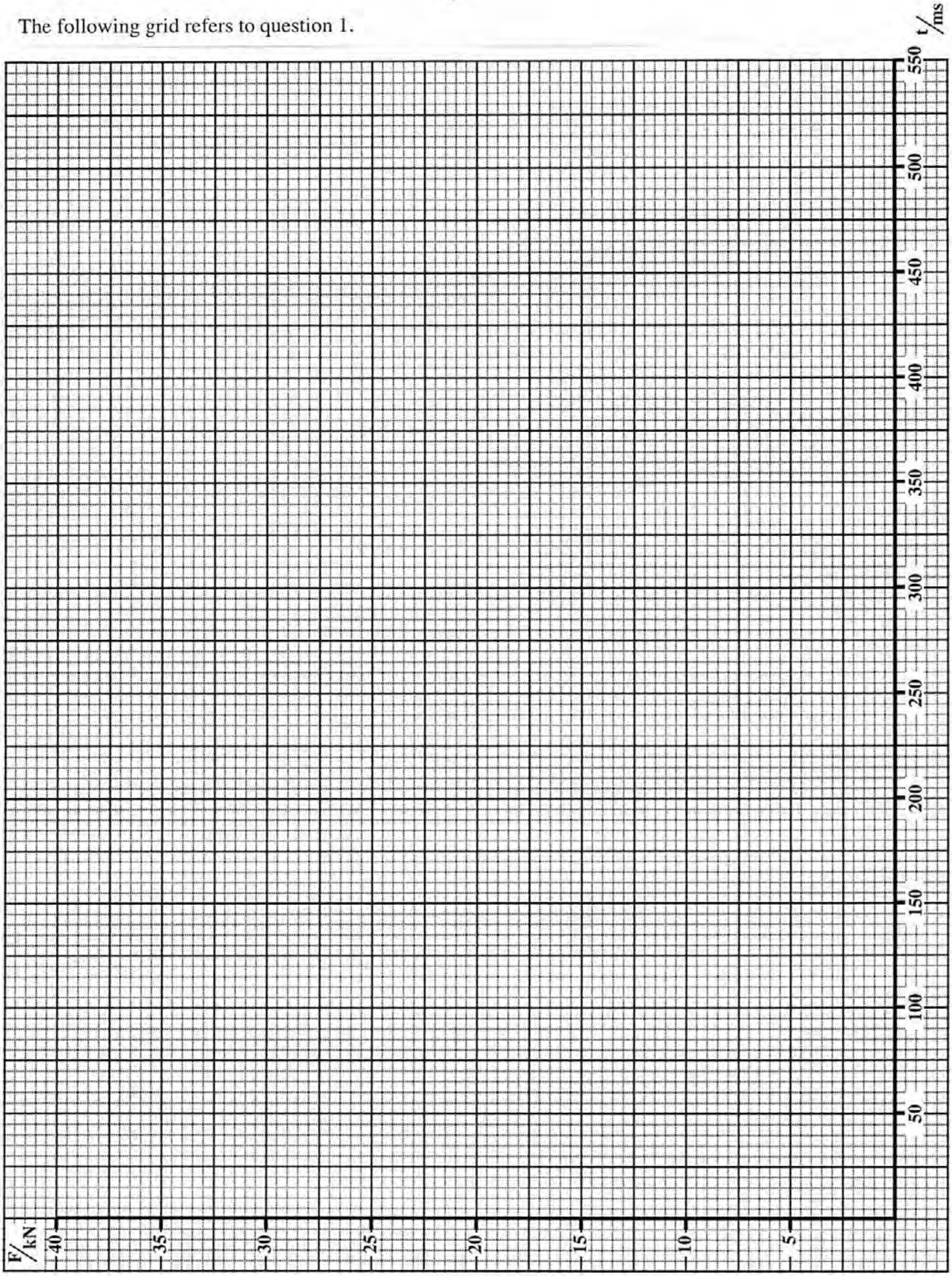
Table 1

t/ms	F/kN
0	0
50	6.5
100	16.5
150	26
200	32.5
250	37.
275	37.5
300	37
350	33
400	26
450	14
500	6
550	1
575	0

(a) Use the data to plot a graph showing how the force on the car varies with time.

[3 marks]

The following grid refers to question 1.



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(b) (i) What physical quantity is represented by the area under the graph?

____

(ii) If the area under the graph is 186 one-centimetre squares what is the value of this quantity using the units given?

[3 marks]

(c) Find the speed of the car just before impact, assuming it came to rest in contact with the wall.

[2 marks]

(d) What was the maximum acceleration experienced by the car?

[2 marks]

Total 10 marks

NOTHING HAS BEEN OMITTED

2. Figure 1 shows an experimental arrangement set up to measure the focal length, f, and position, d, of a converging lens mounted in an inaccessible position inside a cardboard tube AB with windows at both ends. The distance from end A to the screen is x.

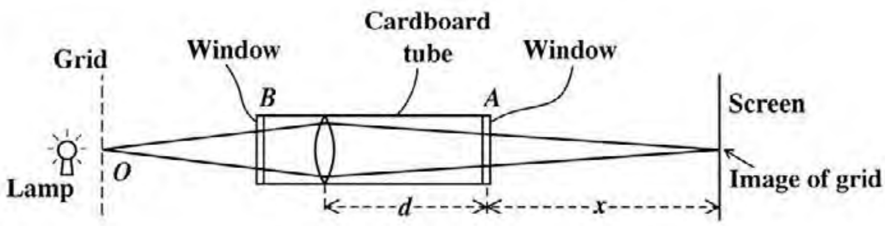

Figure 1

(a) Briefly explain how you would take readings in order to determine the magnification of the image for various values of x.

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____

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____

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[3 marks]

(b) The magnification, m, of the image, is given by $m = \frac{(x + d)}{f} - 1$.

Figure 2 is a plot of m versus x.

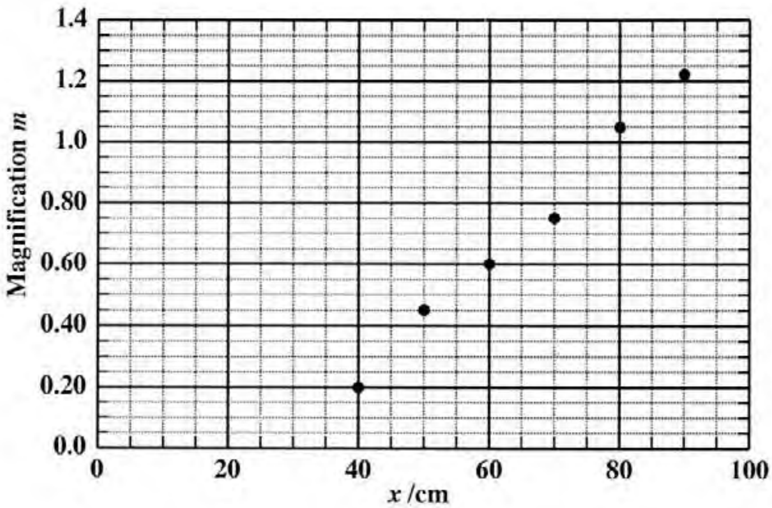

Figure 2

Show that:

(i) the gradient of the graph is $\frac{1}{f}$

[1 mark]

(ii) when $m = 0$, $x + d = f$.

[1 mark]

(c) (i) Draw the best straight line through the points. [1 mark]

(ii) Determine

a) the gradient of the graph

[2 marks]

b) the focal length, f, of the lens

[1 mark]

c) the position d of the lens inside the tube.

[1 mark]

Total 10 marks

GO ON TO THE NEXT PAGE

3. A thermistor is to be calibrated by plotting a graph showing its resistance at various temperatures. The table below shows the data collected.

(a) (i) Draw a circuit diagram showing how the values of the p.d. across the thermistor and the current flowing through it might be measured. **[1 mark]**

(ii) Describe briefly the experimental set-up and suggest ONE precaution which might be taken to ensure accurate values.

____

____

____

____

____

[2 marks]

(b) (i) Complete Table 2 to show the values of the resistance, R.

Table 2

θ/ °C	p.d./V	I/mA	R/Ω
0	2.04	2.74	
10.0	2.03	3.50	
20.0	2.02	5.05	
30.0	1.99	6.75	
40.0	1.97	8.90	
50.0	1.95	11.9	
60.0	1.95	15.9	
70.0	1.95	19.9	
80.0	2.02	28.0	

[2 marks]

(ii) On the page opposite plot a graph of resistance, R, versus temperature, θ.

[4 marks]

(c) Find the temperature indicated by this thermometer when the resistance is 320 Ω.

θ = °C **[1 mark]**

Total 10 marks

GO ON TO THE NEXT PAGE

The following grid refers to question 3(b).

SECTION B

You must attempt THREE questions from this section. Choose ONE question EACH from Module 1, 2 and 3. You MUST write your answers in the separate answer booklet provided.

MODULE 1

Answer EITHER Question 4 OR Question 5.

4. (a) (i) State Newton's laws of motion.

(ii) Explain why a small sphere, released from rest at the surface to fall through liquid in a deep tank, eventually moves with a constant speed. Sketch a graph showing how the acceleration of the sphere varies with time after its release at the surface of the liquid. **[8 marks]**

(b) A large helium weather balloon is spherical in shape with a radius of 2.5 m and a total mass of 15 kg (balloon plus helium plus equipment). The balloon is released from sea level and travels vertically upward, quickly reaching its terminal velocity.

The drag force acting on the balloon is given by

$F_D = \frac{1}{2}\pi r^2 \rho v^2$, where r is the radius of the balloon, ρ is the density of air, and v is the ascension speed of the balloon.

(i) Draw a free body diagram to show the forces acting on the balloon.

(ii) a) Use Archimedes' principle to find the buoyant force acting on the balloon.

b) Calculate the terminal velocity of the balloon.

c) Find the time, in minutes, it will take for the balloon to ascend to a height of 10 km.

(Density of air, $\rho = 1.29$ kg m^{-3}.)

(Volume of a sphere $= \frac{4}{3}\pi r^3$.) **[12 marks]**

Total 20 marks

5. (a) A mass, m, moves with constant linear speed, v, in a circle of radius r. Show that the magnitude of the acceleration, a, of the mass is given by

$$a = \frac{v^2}{r}.$$

[6 marks]

(b) (i) A steel ball of mass m is attached to an inextensible string of length l. The ball is whirled in a vertical circle. Draw diagrams showing the forces acting on the ball when it is *(a)* at the top and *(b)* at the bottom of the circle.

(ii) The speed of the ball is slowly increased. The string breaks if the tension in it exceeds a critical value, T_{max}. Show that when this critical value is reached the angular speed of the ball is given by

$$\omega = \sqrt{\frac{T_{max} - mg}{ml}}$$

(iii) The mass of the ball is 0.5 kg and the string breaks when the angular speed of the ball is 4.0 rad s^{-1}. The length of the string is 1.00 m. Calculate the critical value, T_{max}.

[7 marks]

(c) (i) With the aid of a sketch, describe the motion of the ball after the string breaks at the lowest point of the circle.

(ii) After the string breaks, it takes 0.5 s for the ball to hit the ground.

Calculate

a) the lateral distance the ball travelled during this time

b) the vertical velocity of the ball just before it strikes the ground.

[7 marks]

Total 20 marks

MODULE 2

Answer EITHER Question 6 OR Question 7.

6. (a) Explain the following terms as they relate to the human eye:

(i) Accommodation
(ii) Astigmatism
(iii) Cataract **[3 marks]**

(b) Using lenses with a power of 2.5 D in her glasses, a woman can comfortably read a book held 25 cm from her eyes.

(i) With the aid of a diagram explain the eye defect from which she suffers.

(ii) Determine the woman's near point (i.e. the distance from her eyes where she can see objects clearly without her glasses). **[7 marks]**

(c) To answer this part of the question you may need to refer to the graph below.

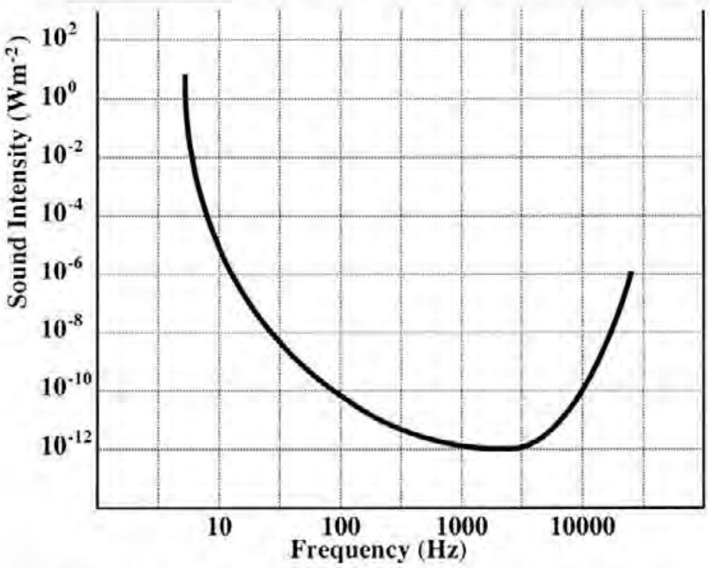

Figure 3: Response curve for the human ear

(i) What intensity of sound is considered to be the threshold of human hearing?

(ii) Why is the response of the human ear said to be logarithmic?

(iii) Explain why sound intensity levels are often measured using a decibel (dB) scale.

(iv) A noisy motorbike emits noise with an intensity of 6×10^{-2} W m^{-2}. What is the intensity level in dB?

(v) Over what range of frequencies would a normal human ear be able to hear a sound with an intensity level of 20 dB? **[10 marks]**

Total 20 marks

GO ON TO THE NEXT PAGE

7. (a) (i) Figure 4 shows an undamped mass-spring system. With the aid of sketch graphs, give an account of the energy transformations which occur during one complete cycle of this system.

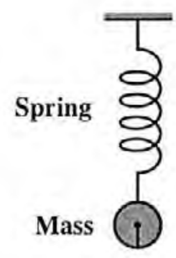

Figure 4

(ii) Explain why a damped oscillating system experiences a progressive decrease in its amplitude

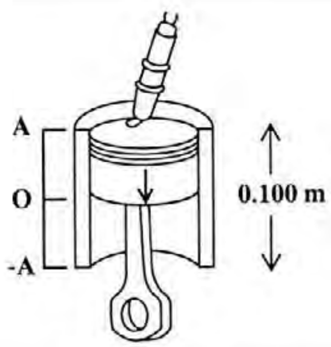

Figure 5

[8 marks]

(b) Figure 5 shows the piston of an automobile engine. The motion of the piston is simple harmonic. The stroke of the engine (twice the amplitude) is 0.100 m and the engine runs at 3500 revolutions per minute. The mass of the piston is 0.450 kg.

Calculate

(i) the acceleration of the piston at the endpoint of the stroke

(ii) the speed of the piston at the midpoint of the stroke

(iii) the kinetic energy of the piston at the midpoint of the stroke

(iv) the average power required to accelerate the piston from rest to the speed found in (b) (ii). **[12 marks]**

Total 20 marks

MODULE 3

Answer EITHER Question 8 OR Question 9.

8. (a) (i) State TWO mechanisms which enable thermal conduction to take place in a metal.

(ii) Explain why only one of the mechanisms is responsible for thermal conduction in an insulator.

(iii) The thermal conductivity, k, of a material may be defined according to the expression

$$\frac{Q}{t} = kA\frac{\Delta\theta}{\Delta x}$$

State the conditions that must be satisfied before the expression may be applied.

(iv) Explain what is meant by the specific latent heat of vaporization of a substance.

[8 marks]

(b) Figure 6 shows a stainless steel pot with a flat base 8.50 mm thick that rests on a hot plate. The area of the bottom of the pot is 0.150 m^2. The water inside the pot is at 100° C, and 0.450 kg of water is evaporated every 3 minutes.

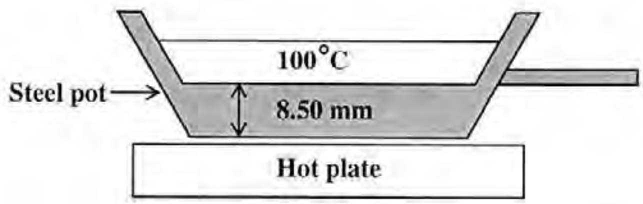

Figure 6

Calculate the surface temperature of the hot plate, which is in contact with the pot. (Coefficient of thermal conductivity, k, for stainless steel = 50.2 W $m^{-1}K^{-1}$)

[5 marks]

(c) The rate, P, at whch an object radiates energy, is proportional to the fourth power of the absolute temperature, T. The intensity of the radiation a distance, r, from the source is given by $I = \frac{P}{4\pi r^2}$.

These relationships may be investigated by using a thermopile connected to a micro-voltmeter and exposing it to the radiation from a small heated sphere that radiates as a point source.

Table 3 shows the micro-voltmeter readings, V, obtained when the sphere was maintained at various temperatures and the thermopile was a distance r from it. The voltage, V, of the thermopile is proportional to the intensity of radiation falling on it.

Table 3

r /m	T /K	V /μV
1.5	1500	4.5
1.5	2250	V_2
r_3	1500	9.0

(i) Suggest how the intensity of radiation reaching the thermopile varies with the absolute temperature, T, of the sphere.

(ii) Determine the values of r_3 and V_2. **[7 marks]**

Total 20 marks

9. (a) (i) State FOUR of the basic postulates of the kinetic theory of an ideal gas.

(ii) Write an expression connecting the pressure of an ideal gas with the mean square speed of the molecules.

(iii) Using the expression you stated above and the ideal gas equation, $pV = nRT$, derive an expression for the total translational kinetic energy of a monatomic gas. **[8 marks]**

(b) Two moles of hydrogen initially at $-10\ ^\circ$C and 1.0×10^5 Pa, expands at constant pressure to five times its initial volume. The molar mass of hydrogen molecules is 2.0×10^{-3} kg mol^{-1}. Calculate

(i) the initial volume of the gas

(ii) the final temperature of the gas

(iii) the work done by the gas in the expansion

(iv) the change in the internal energy of the gas during the expansion

(v) the heat added to the gas

(vi) the root mean square speed, v_{rms} of the hydrogen molecules after the expansion. **[12 marks]**

Total 20 marks

END OF TEST

FORM TP 2006265

TEST CODE **02238010**

MAY/JUNE 2006

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 02 – PAPER 01

1 hour 45 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **NINE** questions. Candidates must attempt **ALL** questions.
2. Candidates **MUST** write in this answer booklet and all working **MUST** be **CLEARLY** shown.
3. The use of non-programmable calculators is permitted.

NOTHING HAS BEEN OMITTED

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
Elementary charge	e	=	1.60×10^{-19} C
The Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration of free fall	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

1. (a) (i) What is the physical reason for copper being a better conductor than a material such as nichrome which is used to make resistors?

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(ii) Sketch a graph to show how the resistance per unit length of a wire varies with the cross-sectional area of the wire.

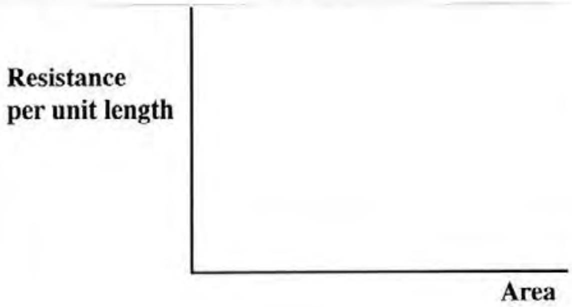


Figure 1

(iii) Write an equation relating the resistance per unit length to the area of the wire.

[3 marks]

(b) A small heater is constructed from nichrome wire with a diameter of 0.45 mm. The heater produces heat at a rate of 25 W from a 9 V supply.

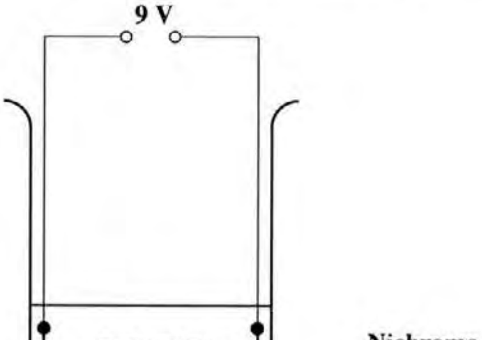


Figure 2

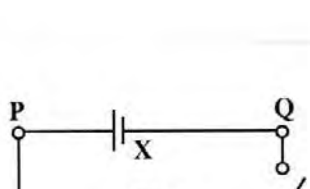
(i) What is the resistance of the heater?

(ii) The length of nichrome wire required to make the heater is 42 cm. Calculate the resistivity of nichrome, remembering to give the correct unit.

[7 marks]

Total 10 marks

2. (a) Complete the circuit below to show how a slide-wire potentiometer could be set up to compare the p.d. across PQ with the switch open to the p.d. when the switch is closed.



[4 marks]

(b) The potentiometer is calibrated so that the p.d. across its 1.00 m wire is 2.00 V.

(i) When the switch is open the balance length is found to be 54.2 cm. What is the e.m.f. of the cell X?

[2 marks]

(ii) When the switch is closed the balance length changes to 36.6 cm. Given that the resistance of R is 5.00 Ω, determine the internal resistance of the cell X.

[4 marks]

Total 10 marks

3. (a) Describe briefly, with the aid of a diagram, a practical application of electrostatics.

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[2 marks]

GO ON TO THE NEXT PAGE

(b) The gowns worn in the operating theatre of a hospital are never made of synthetic materials such as nylon. Suggest a reason for this.

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[2 marks]

(c) An electric field is set up by applying a high voltage between two parallel metal plates 1.5 mm apart.

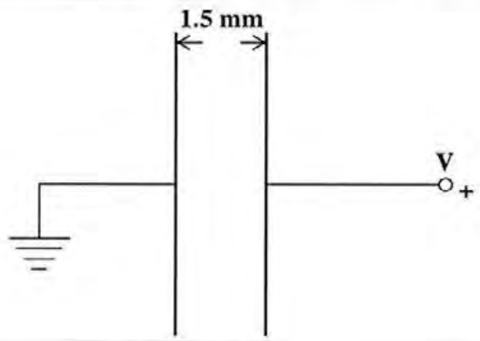

Figure 3

(i) Complete the diagram in Figure 3 to show the electric field between the plates.

[1 mark]

(ii) If the electric field is strong enough sparks will pass through the air between the plates. Explain this process.

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[2 marks]

(iii) Calculate the magnitude of the greatest voltage which may be applied to the plates without causing sparks. The breakdown field strength of dry air is 3×10^6 V m^{-1}.

[3 marks]

Total 10 marks

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4. (a)

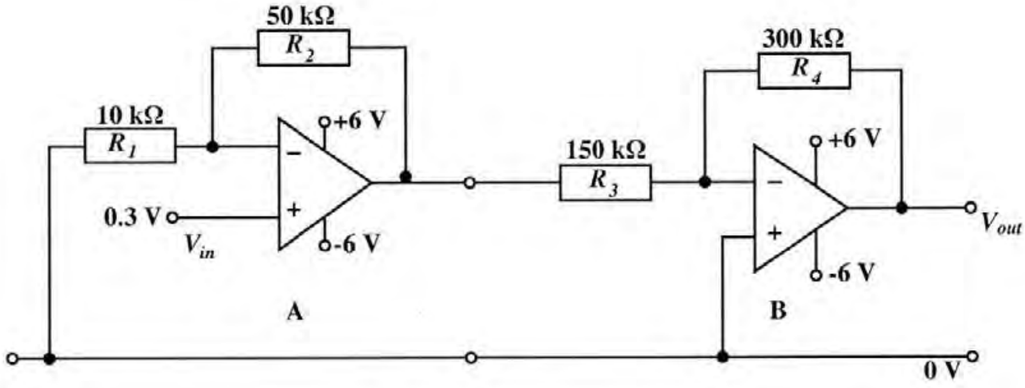


Figure 4

(i) Write the formula for the gain of each of the amplifiers which are cascaded in the diagram above.

A Gain =

B Gain =

[2 marks]

(ii) Mark with an X any point or points on the circuits above which would be regarded as a virtual earth. **[1 mark]**

(iii) If the input voltage is 0.3 V what is the output voltage, V_{out} ?

[3 marks]

GO ON TO THE NEXT PAGE

(b) Three signals V_1, V_2 and V_3 are to be combined to produce an output V_{out} such that

$$V_{out} = -2V_1 - 8V_2 - V_3$$

Design a circuit to achieve this objective using only resistors with values between 15 kΩ and 200 kΩ.

[4 marks]

Total 10 marks

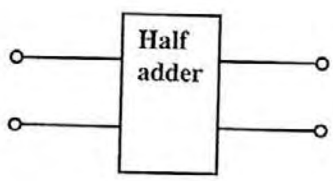
GO ON TO THE NEXT PAGE

5. (a) In the space below draw a circuit diagram to show how a half-adder can be constructed from three other logic gates. Also draw up a truth table to show how it functions.

Input 1	Input 2		

[3 marks]

(b) Complete the circuit below to show how two half-adders and a logic gate may be connected to produce a full-adder.



[2 marks]

(c) (i) Complete the truth table to show the action of the circuit as shown in Figure 5.

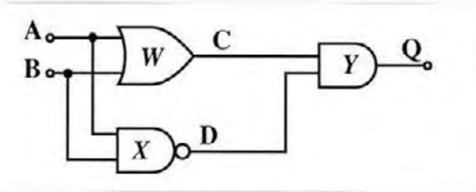


Figure 5

A	B	C	D	Q

[3 marks]

(ii) State the name of the single logic gate which could replace this circuit and draw its usual symbol.

Name ______________________

Symbol

[2 marks]

Total 10 marks

GO ON TO THE NEXT PAGE

6. (a) An alternating signal is represented by the equation:

$V = 150 \sin (400 \pi t)$ (V is in mV and t in seconds.)

(i) What is the frequency of the signal?

[1 mark]

(ii) What is the period?

[1 mark]

(iii) Find the r.m.s. voltage of the signal.

[2 marks]

(iv) Using the axes below, draw the graph to show how the voltage varies with time.

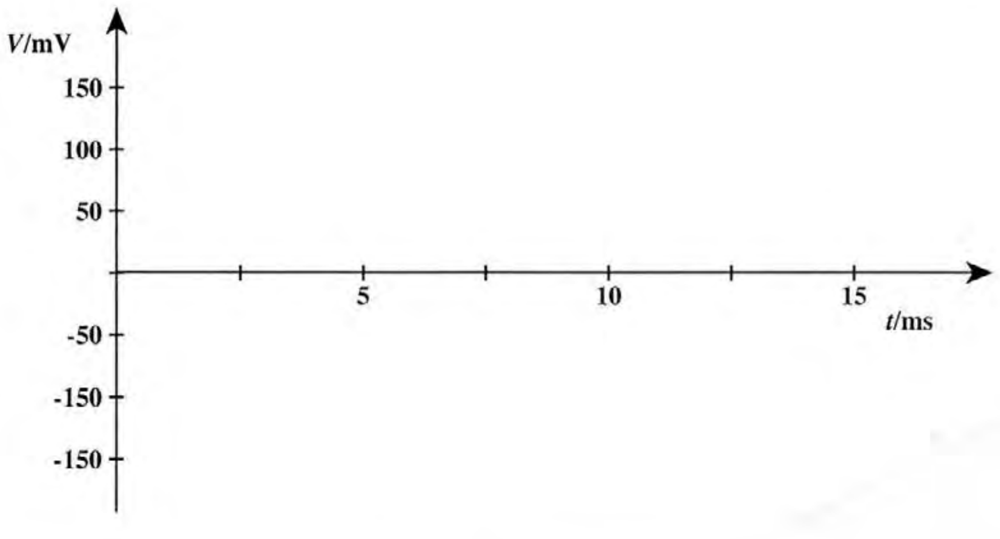


Figure 6

[3 marks]

(b)

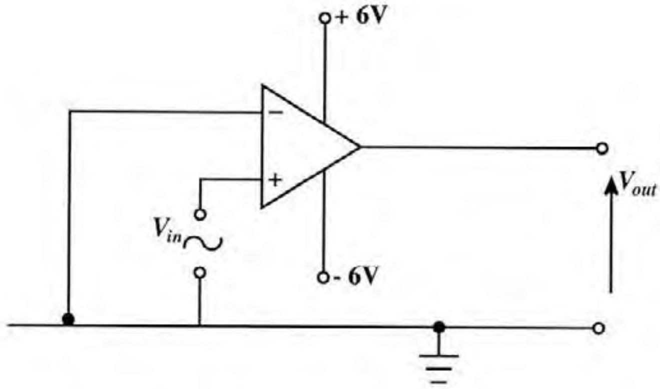


Figure 7

The signal in (a) is applied to the non-inverting terminal of an operational amplifier as shown in Figure 7.

Using the axes below, draw a graph to show how the output varies with time. Show clearly the scale on the vertical axis.

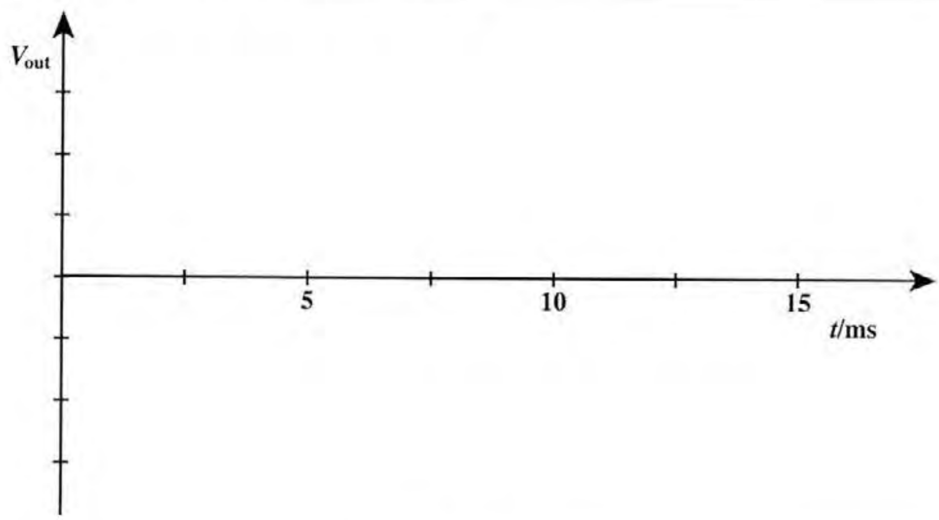


Figure 8

[3 marks]

Total 10 marks

7. (a) Thorium-232 is radioactive and emits α-particles. The daughter product Radium-228 is also radioactive but it decays by β -particle emission. Complete the following equations for these decays:

$$^{232}_{90}Th \rightarrow ^{228}_{88} Ra +$$

$$^{228}_{88}Ra \rightarrow \qquad Ac +$$

[3 marks]

(b) (i) Derive an equation for the radius R of the circular path of a particle with mass, m, and charge, q, moving with a velocity, v, at right angles to a uniform magnetic field, strength B. **[3 marks]**

(ii) An α-particle and a β-particle move with the same velocity through the same perpendicular magnetic field. If the radius of the α-particle's path is 0.40 m what will that of the β-particle be?

[3 marks]

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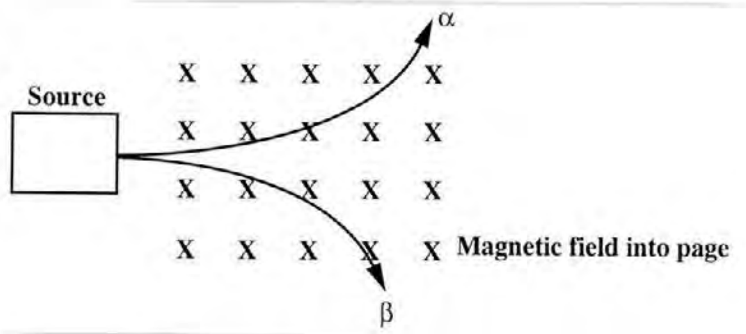

Figure 9

(c) Diagrams similar to the one above are often seen in textbooks. Explain why the diagram is unrealistic.

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[1 mark]

Total 10 marks

8. Figure 10 illustrates an electron beam tube used for observing electron diffraction.

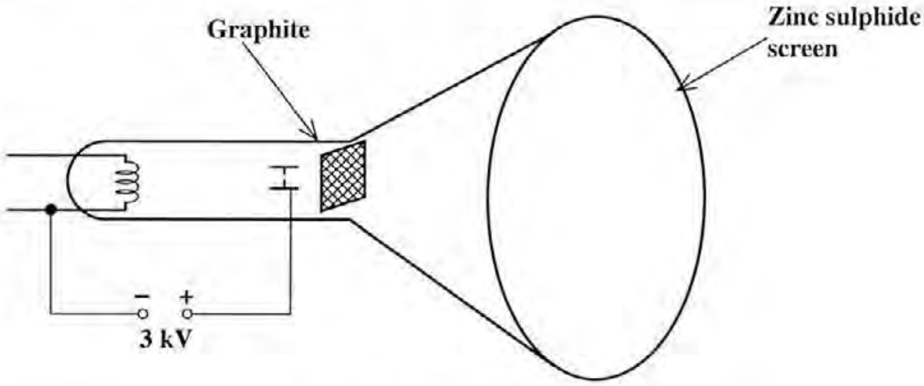

Figure 10

(a) The accelerated electrons are diffracted by the sheet of graphite. Show on the diagram in Figure 10 what you would expect to see on the screen. **[2 marks]**

(b) How fast are the electrons travelling when they have been accelerated through a p.d. of 3000 V ? **[3 marks]**

(c) Calculate the wavelength of the electrons which are emitted from the anode. **[3 marks]**

(d) What changes to the image on the screen would be observed if the accelerating voltage were reduced? **[2 marks]**

Total 10 marks

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9. In the Rutherford scattering experiment, which established the concept of the nuclear atom, alpha particles were fired at very thin pieces of gold foil.

(a) (i) Draw a diagram of the apparatus used in this experiment.

(ii) Suggest a reason why the experiment was conducted in a vacuum.

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[3 marks]

(b) Complete the table below by adding the conclusions which may be drawn from the observations made in the experiment.

Observation	Conclusion
The vast majority of the alpha particles passed through the gold foil without being deflected.	
Some alpha particles were deflected through large angles as they passed through the gold foil.	
A very small number of alpha particles did not penetrate the foil and were detected on the same side of the foil as the α-particle source.	

[3 marks]

(c) The electrons around the nucleus may have only certain allowed energies as shown in the diagram below for a mercury atom. When an electron is in one of the higher, excited, energy states it eventually moves to a lower level and emits a photon of light. Find the wavelength of the light emitted when an electron jumps from Level 3 down to Level 2.

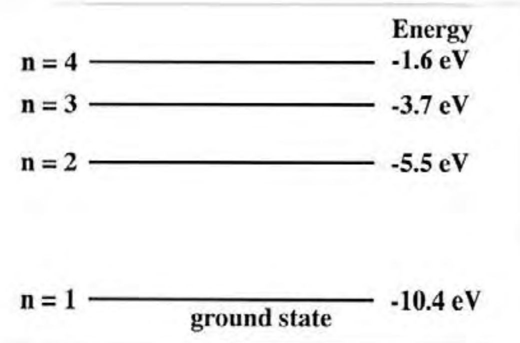

Figure 11

[4 marks]

Total 10 marks

END OF TEST

TEST CODE **02238020**

FORM TP 2006266

MAY/JUNE 2006

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 02 – Paper 02

2 hours 15 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **NINE** questions.
2. Section A consists of **THREE** questions. Candidates must attempt ALL questions in this section. Answers for this section must be written in this answer booklet.
3. Section B consists of **SIX** questions. Candidates must attempt **THREE** questions in this section, **ONE** question from **EACH** Module. Answers for this section must be written in the separate answer booklet provided.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted.

NOTHING HAS BEEN OMITTED

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
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Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration of free fall	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Attempt ALL questions. You MUST write in this answer booklet.

1. The circuit shown in Figure 1 may be used to study the discharge of a capacitor. When the movable contact is connected to P the capacitor charges.

(a) Explain how energy is stored in the capacitor when the switch is connected to P.

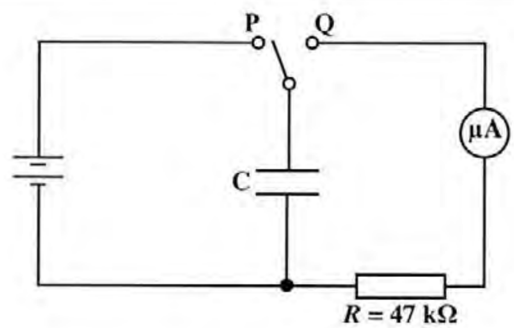

Figure 1

[2 marks]

(b) When the switch is moved to Q the stored energy is discharged and causes a current to flow through the resistor, R. The graph opposite shows how the discharge current through the resistor varies with time. The equation of the graph is:

$$I = I_0 e^{-\frac{t}{RC}}$$

(i) Use data from the graph to complete the table below and then plot a graph of ln I against t.

Table 1

t/s	I/μA	ln(I/μ A)
20.0	36.6	3.60
60.0		
100.0	16.5	2.80
140.0		
180.0	6.5	1.87
220.0		

[4 marks]

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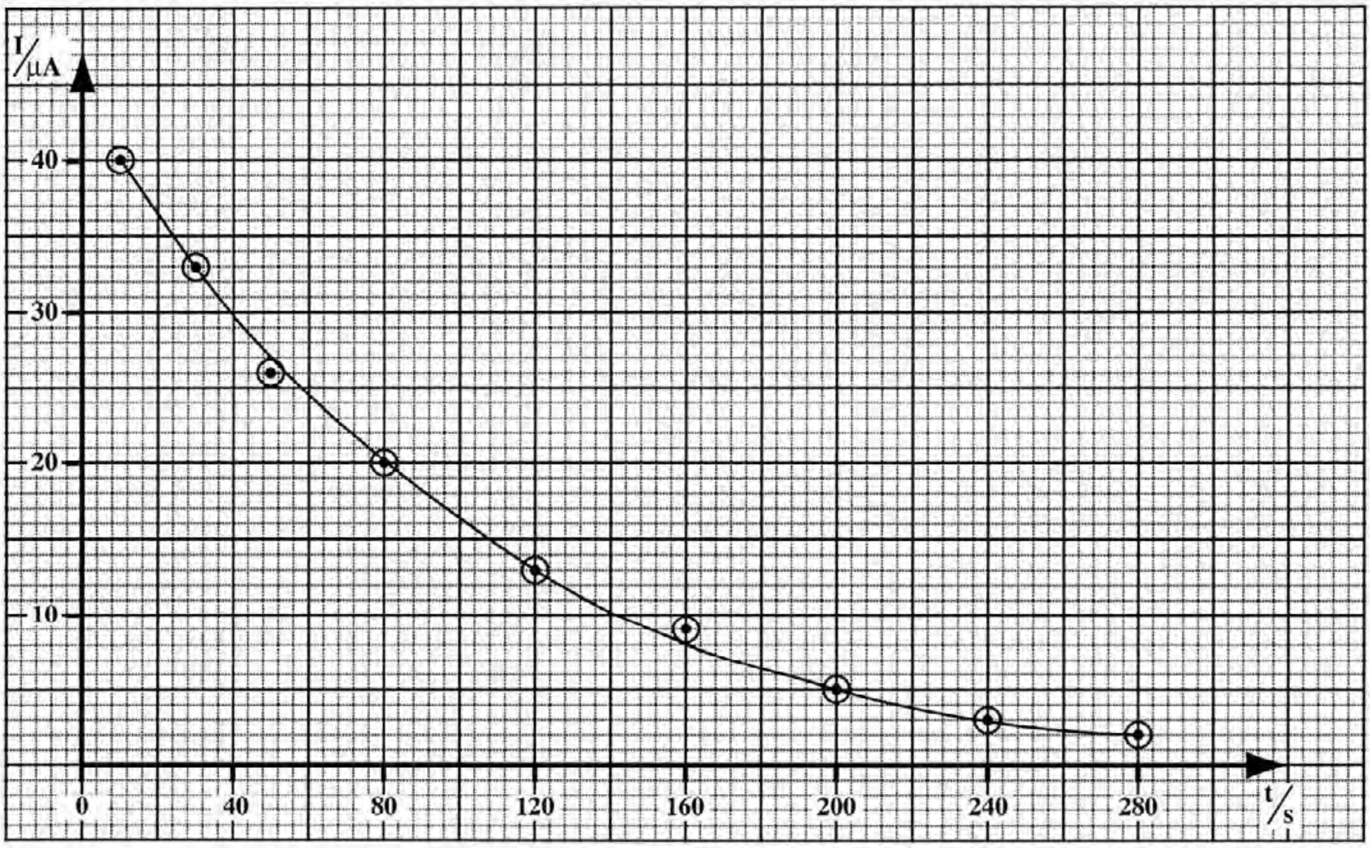
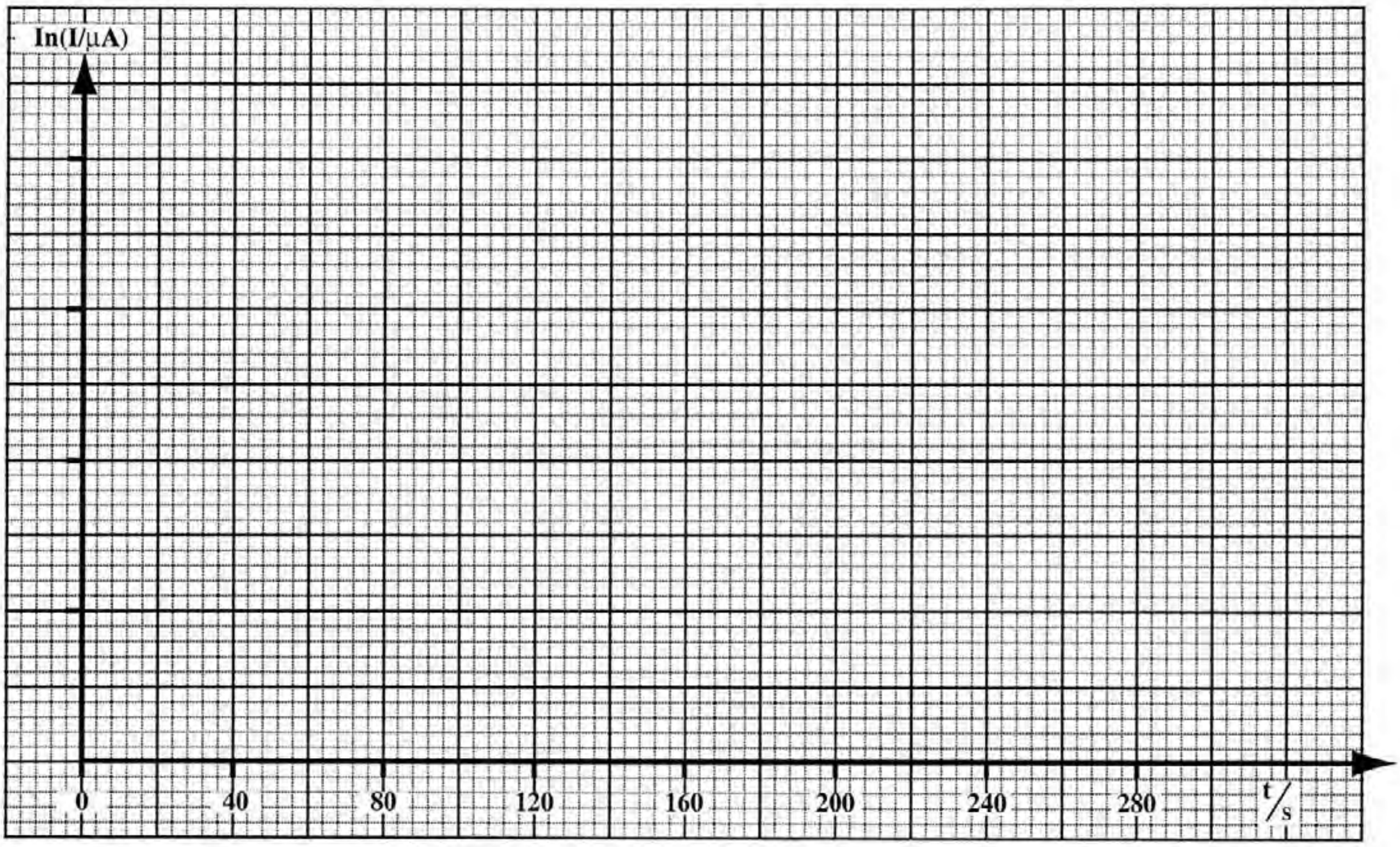
Capacitor Discharge





(ii) What is the equation of this new graph? **[1 mark]**

(c) (i) Find the gradient of the graph you have drawn. **[1 mark]**

(ii) Given that R has a resistance of 47 kΩ, deduce the capacitance of the capacitor C.

[2 marks]

Total 10 marks

2. Table 2 on the right shows the values of the input voltage to an inverting amplifier and the corresponding values of the output voltage.

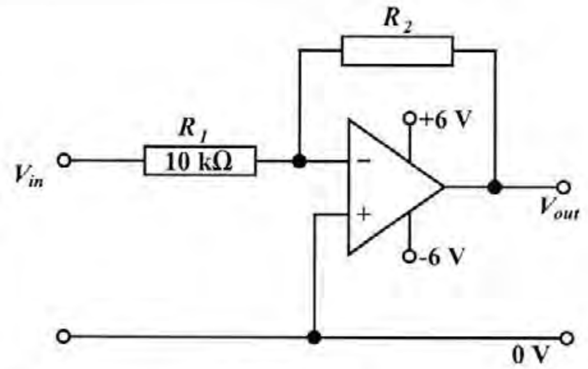


Figure 2

Table 2

V_{in}/V	V_{out}/V
-3.00	5.78
-2.00	5.78
-1.00	5.78
-0.75	5.78
-0.50	4.92
-0.30	2.97
-0.10	0.97
0.15	-1.49
0.25	-2.45
0.50	-4.89
0.75	-5.66
1.00	-5.66
2.00	-5.66
3.00	-5.66

(a) Use the data in the table to plot the transfer characteristic (V_{out} versus V_{in}) of the amplifier. **[4 marks]**

GO ON TO THE NEXT PAGE

The following graph refers to question 2.

(b) Determine the gradient of the linear region of the graph.

[2 marks]

(c) (i) If R_1 is 10 kΩ what is the resistance of R_2?

[2 marks]

(ii) What is the largest positive input voltage which can be used if the amplifier is not saturated?

[2 marks]

Total 10 marks

3. (a) In Millikan's experiment to determine the charge of the electron, a small drop of oil is held stationary between two parallel charged plates (Figure 3) when the weight of the drop is balanced by the electric force (i.e. when $mg = qE$).

(i) How much charge is on the drop of mass 3.9×10^{-15} kg when it is held stationary by a p.d. of 200 V between plates 10 mm apart?

(ii) How could the charge on this drop be changed?

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(iii) To hold the drop stationary when the charge changes the p.d. must be adjusted. Draw a diagram of a circuit which could be connected to P and Q to achieve this, assuming that a power supply with a fixed output of 400 V d.c. is available.

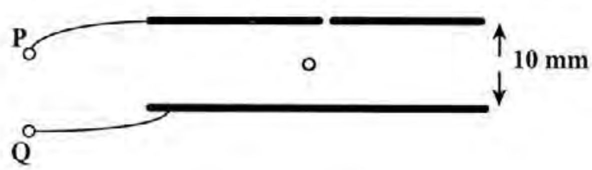

Figure 3

[4 marks]

(b) Table 3 below shows the charges (in arbitrary units) on a single oil drop measured in an experiment like the one above. (N.B. The units of charge used are NOT coulombs.)

Table 3

Result #	**Charge**	**Result #**	**Charge**	**Result #**	**Charge**
1	18	11	33	21	12
2	24	12	15	22	15
3	15	13	21	23	24
4	30	14	15	24	12
5	21	15	12	25	6
6	24	16	27	26	33
7	6	17	30	27	24
8	18	18	18	28	18
9	21	19	21	29	30
10	18	20	6	30	12

(i) Plot a scatter graph of charge against result number on the grid opposite.

(ii) How do these results suggest that charge is quantized?

____

____

____

(iii) Deduce the value of the charge on the electron (in arbitrary units) implied by these data.

[6 marks]

Total 10 marks

The following graph refers to question 3 (b) (i).

SECTION B

You must attempt THREE questions from this section. Choose ONE question EACH from Module 1, 2 and 3. You MUST write your answers in the separate answer booklet provided.

MODULE 1

Answer EITHER Question 4 OR Question 5.

4. (a) (i) Explain the term 'drift velocity'.

(ii) Define the 'coulomb' and the 'volt'.

(iii) Figure 4 shows electrons moving through a cross section of a wire. Show that the current, I, through the wire is given by $I = nevA$

where
n is the number density of the electrons,
e is the charge on the electron,
v is the drift velocity of the electrons, and
A is the cross sectional area of the wire.

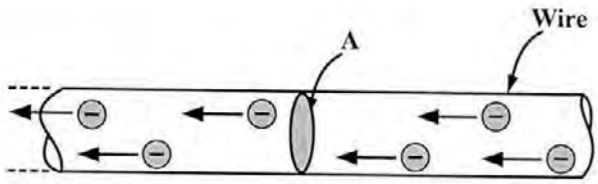

Figure 4

[8 marks]

(b) A cylindrical proton beam of kinetic energy 5.0 MeV and radius 1.5 mm is aimed at a target. The beam carries a current of 0.50 mA.

Calculate:

(i) The velocity of the protons
(ii) The number density of protons in the beam
(iii) The number of protons hitting the target in 1 second **[9 marks]**

(c) The beam of protons in (b) is to be deflected around a curve of radius 2.0 m. If the magnetic field is perpendicular to the beam, calculate its field strength.

[3 marks]

Total 20 marks

5. (a) (i) Define 'magnetic flux density' and the 'tesla'.

(ii) Sketch the magnetic flux pattern due to a long straight wire carrying a current, and state the formula for the flux density, B, at a distance, r, from the wire.

(iii) Figure 5 shows two long parallel wires, both of length l, separated by a distance, r, carrying currents, I_1 and I_2, in opposite directions.

Show that the force between the two wires is given by $F = \frac{\mu_0 I_1 I_2 l}{2\pi r}$.

State whether this force is attractive or repulsive. **[8 marks]**

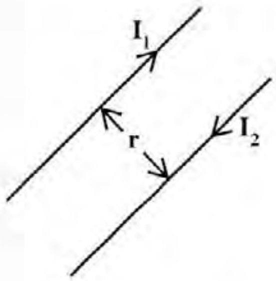

Figure 5

(b) Figure 6 shows a diagram of a current balance constructed in the following way: A 10 cm long section of wire is placed on top of the pan of an electronic balance. Leads are clipped to the wire running into a power supply and through the power supply to another segment of wire that is suspended directly above the wire and parallel with it. The distance between the two wires is 2.5 cm. The power supply provides a current, I, running through the wires. **The force on the lower wire is the increase in the reading of the balance.** When the power is switched on, the reading on the balance increases by 5.0×10^{-6} N.

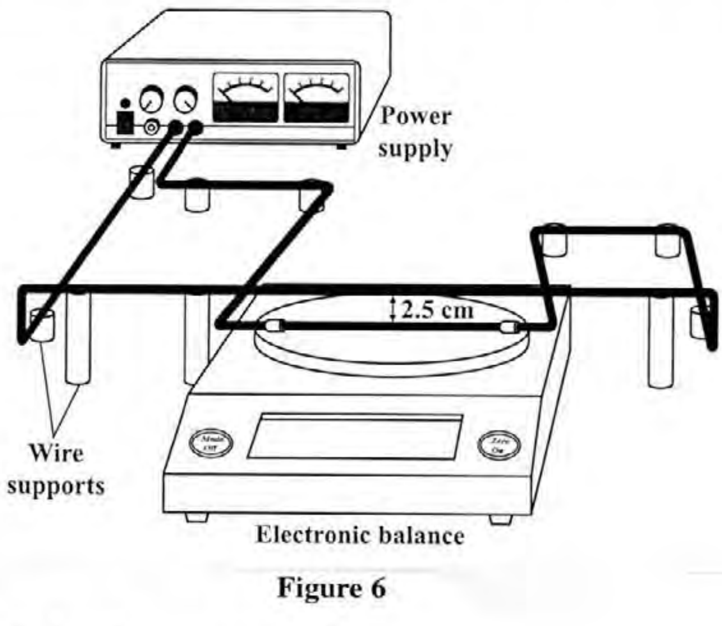

Figure 6

(i) Calculate the current through the wire.

(ii) The sensitivity of the balance is 0.1×10^{-6} N. Calculate the minimum current detectable using this balance. **[6 marks]**

(c) A solenoid is designed to produce a magnetic field of 0.0270 T at its center. It has a radius of 1.40 cm and length 40.0 cm. The wire carries a maximum current of 12.0 A.

Calculate

(i) the minimum number of turns per unit length that must be used

(ii) the total length of wire required. **[6 marks]**

Total 20 marks

MODULE 2

Answer EITHER Question 6 or Question 7.

6. The graph in Figure 7 shows how the gain of an operational amplifier varies with frequency.

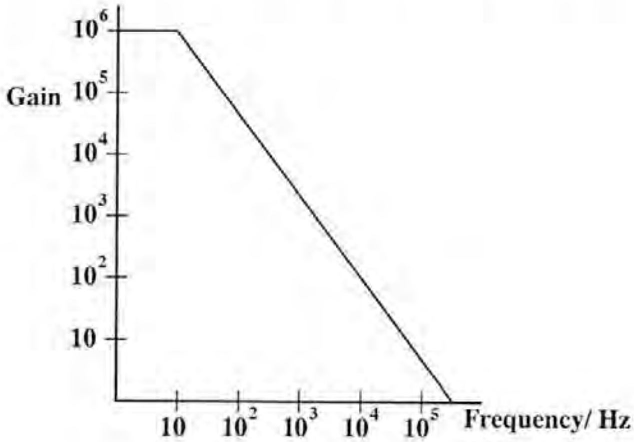

Figure 7

(a) (i) Explain why the scales on the axes are logarithmic rather than linear.

(ii) What value does the graph give for the open loop gain of the op-amp.? **[2 marks]**

(b) (i) A non-inverting amplifier with a gain of +100 is constructed using this op-amp. Use the graph to determine its bandwidth.

(ii) Draw a circuit diagram to show how the non-inverting amplifier could be constructed.

(iii) Write the formula for the gain of this amplifier.

(iv) State the ratio of the feedback resistance to resistance of the input resistor in this non-inverting amplifier. **[6 marks]**

In the circuit shown in Figure 8 the **same** op-amp. is connected as a comparator.

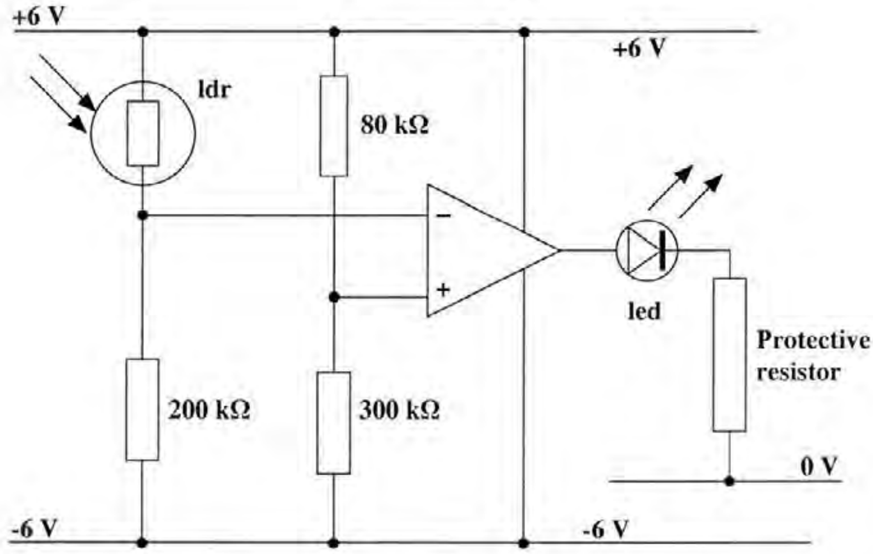

Figure 8

(c) Using your answer to (a) above determine the maximum input voltage to the op-amp. if it is not saturated. **[2 marks]**

(d) (i) Find the potential at the non-inverting terminal of the op-amp in Figure 8.

(ii) In the dark the resistance of the light-dependent resistor (ldr) is 400 kΩ. Find the potential at the inverting terminal in this situation and use this value to explain why the light emitting diode (led) switches on. **[7 marks]**

(e) The led in the circuit is rated 2.4 V, 25 mA. A protective resistor, as shown, has to be connected in series with it so that it does not burn out. What is the value of this resistance? **[3 marks]**

Total 20 marks

7. (a) Many items of equipment in the home are controlled by digital processors (microprocessors).

(i) Name an item found in the home which is controlled by a microprocessor.

(ii) State the function of the microprocessor in the item you have named.

(iii) State TWO benefits resulting from the use of microprocessors.

[4 marks]

(b) (i) Figure 9 illustrates a circuit which has inputs, I_1 and I_2, and output, X.

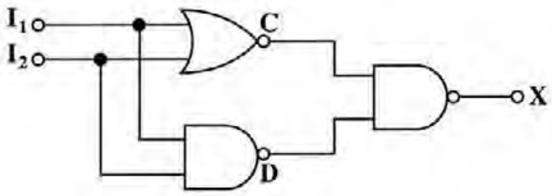

Figure 9

Identify the logic gates shown in Figure 6 and write out their respective truth tables.

(ii) Draw the truth table for the entire circuit shown in Figure 6 and state its function. **[6 marks]**

(c) A student designed a logic circuit using NAND gates and a light-emitting diode (led) in order to monitor the opening and closing of two doors. Logic 1 represents a closed door; logic 0 represents an open door. A logic 1 output is required when only one or the other of the doors is open, but not when both are open.

(i) Write the truth table for the circuit.

(ii) Draw the logic circuit which uses only NAND gates and a single led to indicate logic 1 output.

(iii) What single logic gate is the circuit in (b) (ii) equivalent to? **[5 marks]**

(d) Figure 10 shows a power supply. The four ideal diodes P, Q, R and S are connected to form a bridge rectifier circuit.

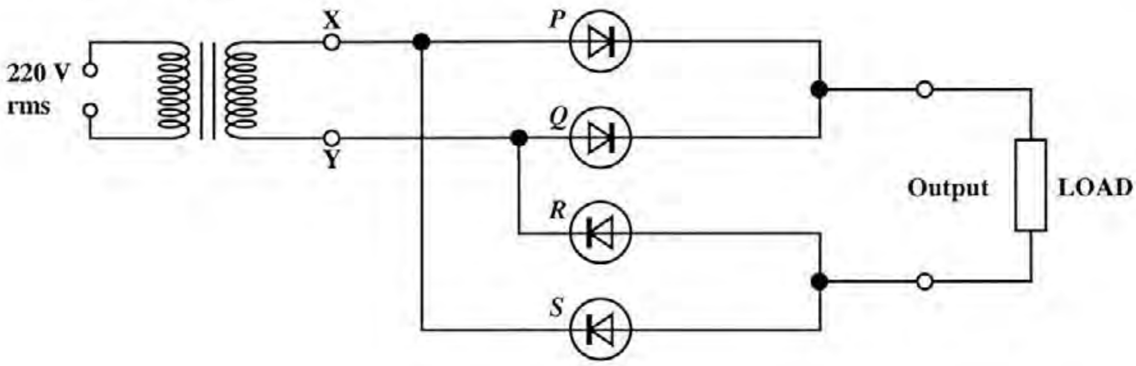

Figure 10

(i) State which diodes conduct when terminal X is positive with respect to terminal Y.

(ii) The input terminals X and Y are connected to the secondary coil of an ideal transformer. The primary coil contains 22000 turns and is connected to a 220 $V_{r.m.s}$ alternating supply. The input to the bridge rectifier circuit is 10 $V_{r.m.s.}$ Calculate the number of turns needed in the secondary coil of the transformer. **[5 marks]**

Total 20 marks

GO ON TO THE NEXT PAGE

MODULE 3

Answer EITHER Question 8 or Question 9.

8. (a) With reference to the photoelectric effect explain what is meant by 'wave-particle duality', 'stopping potential', the 'work function' and 'the threshold wavelength'. **[4 marks]**

(b) Explain why

(i) the maximum kinetic energy of electrons emitted in the photoelectric effect does not depend on the intensity of the incident light

(ii) the total number of electrons emitted depends on the intensity of the incident light. **[4 marks]**

(c) Tungsten has a work function of 4.58 eV. The metal is illuminated with light of wavelength 2.00×10^{-7} m.

Calculate

(i) the threshold wavelength

(ii) the maximum kinetic energy, in eV, of the photoelectrons

(iii) the stopping potential

(iv) the maximum velocity of the photoelectrons. **[12 marks]**

Total 20 marks

9. (a) (i) Explain what is meant by the terms, 'activity', 'decay constant', and 'half life' of a radioactive sample.

(ii) Write an equation relating the activity to the decay constant.

(iii) Show that the half life, $t_{\frac{1}{2}}$, is related to the decay constant, λ, by $t_{\frac{1}{2}} = \frac{ln\,2}{\lambda}$.

(iv) What school laboratory instrument can be used to detect alpha and beta radiation? **[8 marks]**

(b) A radioactive source has a half life of 1 minute. At time $t = 0$, the radioactive source is placed near a detector and the count rate is observed to be 2000 counts/s. The detection efficiency is 20 per cent.

Determine:

(i) the initial decay rate of the source

(ii) the number of nuclei present initially

(iii) the activity of the source after 30 seconds

(iv) the number of nuclei that decay in the first 10 minutes.

[12 marks]

Total 20 marks

END OF TEST

TEST CODE **02138020**

FORM TP 2008246

MAY/JUNE 2008

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 01 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **SIX** questions.
2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.
3. Section B consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the separate answer booklet provided.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

NOTHING HAS BEEN OMITTED

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water		=	1.00×10^{3} kg m^{-3}
Specific heat capacity of water		=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice		=	3.34×10^{5} J kg^{-1}
Specific latent heat of vaporization of water		=	2.26×10^{6} J kg^{-1}
Avogadro's constant	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan-Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in free space	c	=	3.00×10^{8} m s^{-1}

GO ON TO THE NEXT PAGE

SECTION A

Attempt ALL questions.

You MUST write your answers in this answer booklet.

1. (a) Table 1 shows the data collected in a terminal velocity experiment. A small lead sphere of mass m and radius r was timed as it fell through glycerine contained in a long tube at 30 °C.

Table 1

Time, t/s	Velocity, V/m s^{-1}
0	0
0.4	2.53
0.8	3.51
1.2	3.89
1.6	4.03
2.0	4.09
2.4	4.11
2.8	4.12
3.0	4.12

(i) On the grid on page 5, plot a graph of velocity, V, against time, t. **[5 marks]**

(ii) Explain the shape of the graph and use it to identify the terminal velocity, V_t, of the sphere.

____

____

[2 marks]

(iii) Determine the average acceleration of the sphere between $t = 0.5$ s and $t = 0.7$ s.

[2 marks]

(b) The terminal velocity, V_t, of the lead sphere, is given by

$$V_t = \frac{mg}{6\pi kr}$$

where k is a temperature-dependent constant that determines the resistance to motion in the fluid.

(i) Determine the units of k.

[3 marks]

(ii) Given that $m = 5 \times 10^{-3}$ kg, and $r = 1 \times 10^{-3}$ m, determine the value of k for glycerine at 30 °C.

[2 marks]

(iii) Explain how the terminal velocity will be affected if a sphere of the same mass but twice the radius is used.

____

____

[1 mark]

Total 15 marks

2. (a) Explain how a stringed instrument such as a guitar produces a musical note.

[2 marks]

(b) The apparatus shown in Figure 1 may be used to investigate waves on strings.

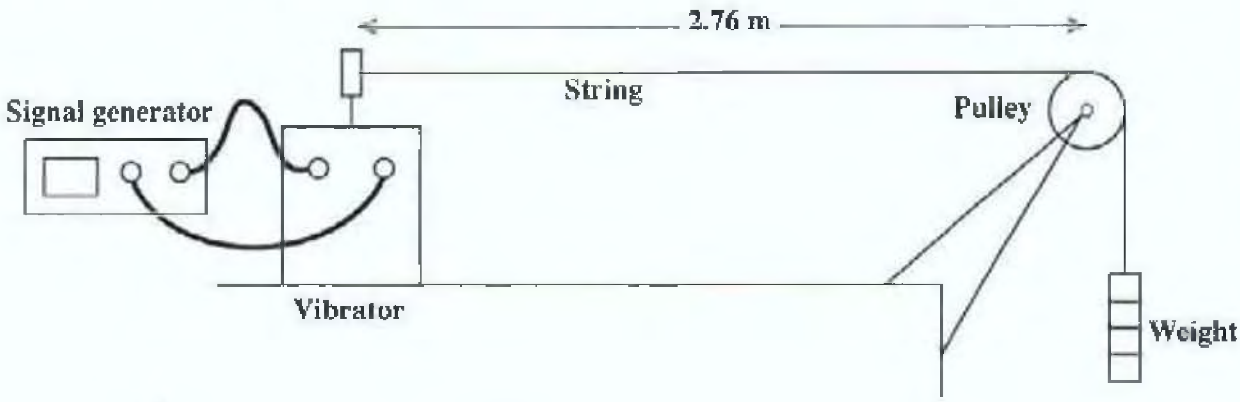

Figure 1

(i) By varying the setting on the signal generator a standing wave with 3 anti-nodes may be set up on the string. In the space below draw a diagram to show how the string would look when this standing wave is set up. (Note: There is no need to draw the vibrator or pulley.)

[1 mark]

(ii) Calculate the wavelength of the wave you have drawn.

[1 mark]

GO ON TO THE NEXT PAGE

(iii) Write an equation for the wavelength when the string has n anti-nodes and use this to show that the relationship between the frequency of the vibrator and the number of anti-nodes is $f = \frac{v}{2L}\ n$

where v is the wave velocity and L (= 2.76 m) is the length of the string.

[3 marks]

(c) The data in the Table 2 were collected using the apparatus in Figure 1 on page 7. By means of plotting a suitable graph on page 8, find the velocity of the waves on the string.
[5 marks]

Table 2

***f*/Hz**	8.6	16	25	35	42	52	62	69
No. of anti-nodes, n	1	2	3	4	5	6	7	8

Calculations

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

3. (a) List ONE advantage and ONE disadvantage of using a liquid in glass thermometer, a thermocouple and a constant volume gas thermometer to measure temperature.

Themometer	Advantage	Disadvantage
Liquid in glass thermometer		
Thermocouple		
Constant volume gas thermometer		

[6 marks]

(b) Figure 2 shows the setup of the experimental arrangement to determine the boiling point of a liquid. The following apparatus is available: a constant volume gas thermometer, large beaker, electric heater, ice, distilled water, liquid, ruler and a stirrer.

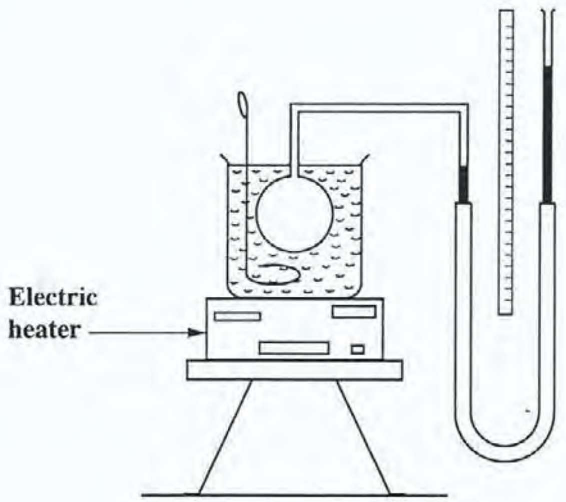

Figure 2

The boiling point, t, of the liquid on the empirical centigrade scale is given by

$$t = 100 \frac{h_t - h_o}{h_{100} - h_o}$$

where h_o is the height of the mercury column at 0 °C, h_{100} is the height of the mercury column at 100 °C and h_t, the height of the mercury column at t °C.

GO ON TO THE NEXT PAGE

(i) How would you ensure that the volume of gas in the bulb is held constant?

[1 mark]

(ii) Carefully explain how readings are taken to determine

a) h_o, the height of the mercury column at 0 °C

b) h_{100}, the height of the mercury column at 100 °C

c) h_t, the height of the mercury column at t °C.

d) Indicate on the diagram (Figure 2) where the height, h, is to be measured.

[4 marks]

(c) The following results were obtained:

$h_o = 5.0$ cm

$h_{100} = 20.0$ cm

$h_t = 16.8$ cm

(i) Using the above results, determine the boiling point of the liquid.

[1 mark]

(ii) Determine the pressure of the gas in the bulb when the liquid is at its boiling point.

Density of mercury 13 600 kg m^{-3}

Atmospheric pressure, 76 cm Hg

Acceleration due to gravity, $g = 9.81$ m s^{-2}

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

SECTION B

Attempt ALL questions.

You MUST write your answers in the answer booklet provided.

4. (a) A body of mass, m, is moving in a circle of radius, r, with constant speed v.

(i) Explain why there must be an acceleration experienced by the mass although it is moving at constant speed.

(ii) Write an expression for the magnitude of the acceleration and state the direction of this acceleration.

(iii) Explain why the work done by the centripetal force on the mass is zero.

[5 marks]

(b) Figure 3 shows a pendulum with string of length 0.5 m and mass 1 kg being whirled at constant speed in a horizontal circle. The mass is 1.5 m above the ground.

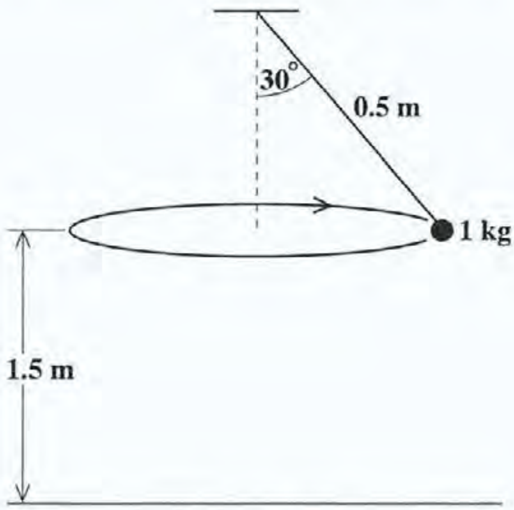

Figure 3

(i) Draw the free body diagram showing the forces acting on the mass.

(ii) Calculate

a) the tension in the string

b) the speed of the mass. **[6 marks]**

(c) During the motion the string suddenly breaks.

(i) Describe the subsequent motion of the mass.

(ii) Calculate the time it takes for the mass to hit the ground after the string breaks.

[4 marks]

Total 15 marks

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5. (a) A diffraction grating is illuminated by a parallel beam of light with a mixture of three wavelengths in the yellow, blue and red parts of the visible spectrum as shown in Figure 4.

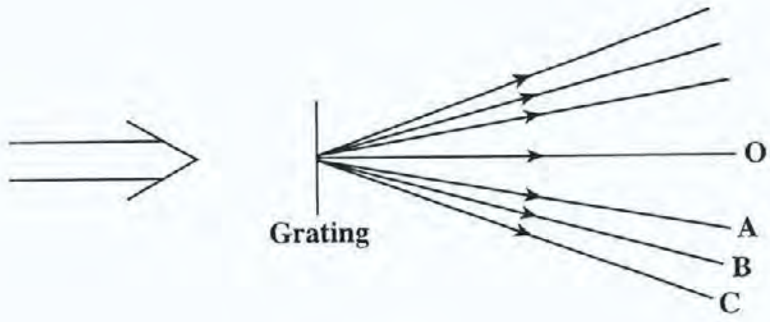

Figure 4

(i) Discuss with the aid of suitable diagrams the role of *diffraction* and *interference* of waves in the production of this spectrum.

(ii) Explain why Beam A in Figure 4 must be the blue light and also identify the colours of the Beams B and C.

(iii) Why does the central beam (labelled O) contain a mixture of all three colours?

[8 marks]

(b) The spectrum of sodium contains two yellow lines close together with wavelengths of **589** nm and **590** nm as shown in Figure 5.

Sodium D lines

Figure 5

To view these lines separately an experimenter used a diffraction grating with $\mathbf{6 \times 10^5}$ lines per metre and the highest order spectrum possible.

(i) Calculate the value of the HIGHEST order spectrum which can be used to view the sodium lines.

(ii) What is the angular separation of the two sodium lines in this spectrum?

[7 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

6. (a) The first law of thermodynamics is given by the equation

$$\Delta U = Q + W.$$

(i) Explain the meaning of EACH of the terms used in the equation when the law is applied to the heating of a fixed mass of gas.

(ii) Use the first law of thermodynamics to explain why the molar heat capacity at constant pressure, C_p, is greater than the molar heat capacity at constant volume, C_v. **[6 marks]**

(b) One mole of an ideal monatomic gas, $C_v = \frac{3}{2}R$, is taken through the cycle represented by states 1 to 4 as shown in Figure 6.

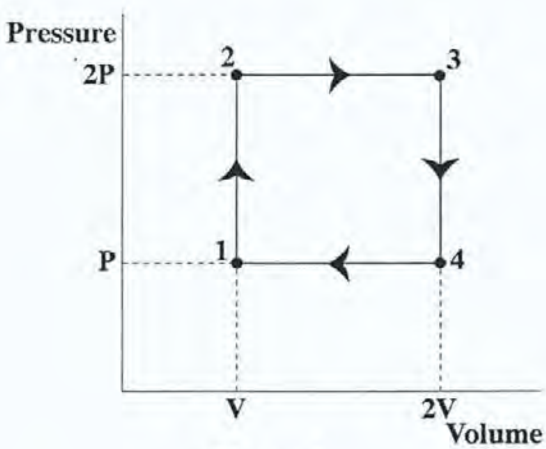

Figure 6

Assume that at state 1, $P_1 = 1.01 \times 10^5$ Pa, $V_1 = 0.0225$ m^3 and $T_1 = 273$ K and at state 3, $T_3 = 1092$ K.

Calculate

(i) the work done during the cycle

(ii) the temperature T_2 at state 2

(iii) the energy added as heat during the processes $1 \rightarrow 2$ and $2 \rightarrow 3$

(iv) the efficiency of the cycle.

[9 marks]

Total 15 marks

END OF TEST

FORM TP 2008246

TEST CODE **22138020**

MAY/JUNE 2008

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 1 – PAPER 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **SIX** questions.
2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.
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Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water		=	1.00×10^3 kg m^{-3}
Specific heat capacity of water		=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice		=	3.34×10^5 J kg^{-1}
Specific latent heat of vaporization of water		=	2.26×10^6 J kg^{-1}
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Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan-Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in free space	c	=	3.00×10^8 m s^{-1}

SECTION A

Attempt ALL questions.

You MUST write your answers in this answer booklet.

1. (a) Using electronic timing the following data in Table 1 was obtained for a steel ball bearing falling from rest. Use the data to plot a suitable straight line graph (on page 5) to determine the value of, g, the acceleration of free fall. **[6 marks]**

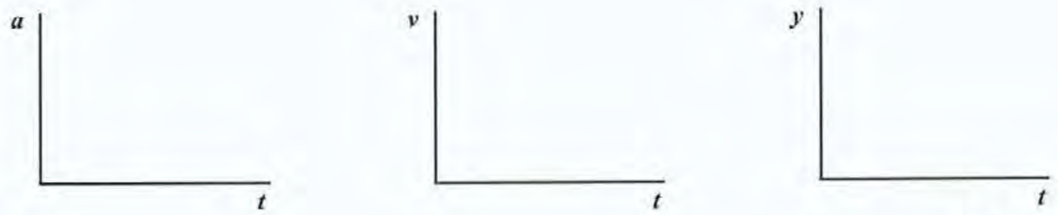
TABLE 1

Distance, y/m	**Time, t/s**	t^2/s^2
$\pm$ 2 mm	**$\pm$ 2 ms**	–
0.400	0.281	
0.600	0.342	
0.800	0.414	
1.000	0.456	
1.200	0.500	
1.400	0.534	

Working for determination of g.

[3 marks]

(b) On the axes below **sketch** graphs (using down as positive) to show how the acceleration, a, velocity, v, and displacement, y, of the falling steel bearing vary with time.



[3 marks]

(c) Using $g = 9.8 \text{ m s}^{-2}$ rather than the value from (a), find the velocity of the steel bearing after it has fallen a distance of 0.90 m.

[3 marks]

Total 15 marks

2. (a) (i) What is meant by the term 'diffraction'?

[1 mark]

(ii) Plane waves incident on small apertures are represented in Figure 1 below. Show on the diagram, the resulting waves after passage through the slits.

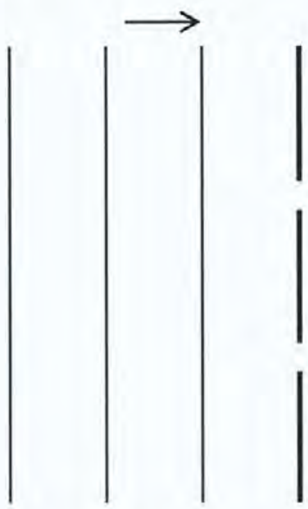


Figure 1

[2 marks]

(iii) Mark on Figure 1, TWO places where constructive interference occurs and TWO places where destructive interference occurs. [Use a circle O for constructive interference and an X for destructive interference.] **[2 marks]**

(iv) In the space below draw wave diagrams to show how TWO waves could superpose to produce constructive and destructive interference. **[2 marks]**

(b) Two vertical dipole antennas, A and B, emit coherent signals from a radio station broadcasting at a frequency of 900 kHz as shown in Figure 2. The antennas are spaced 600 m apart.

Figure 2

(i) A maximum intensity of the signal is received at P some distance away on the line perpendicular to AB as shown and the next maximum is detected at R on a line at an angle θ. Calculate the value of θ.

[5 marks]

(ii) Explain why at Q, a point midway between P and R, the signal received is very weak.

____

____

[1 mark]

(iii) At what angle to the mid-line would the next minimum of the interference pattern occur?

[2 marks]

Total 15 marks

3. (a) (i) Explain what is meant by EACH of the following terms.

'Stress':

____

____

____

____

____

[1 mark]

'Strain':

____

____

____

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[1 mark]

(ii) Figure 3 shows a graph of applied force F, against extension, Δl, for a long steel wire. Mark on the graph the region where the wire obeys Hooke's law.

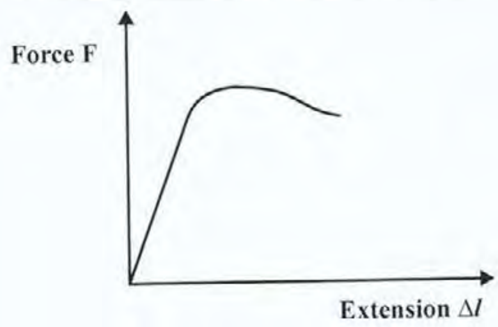


Figure 3

[1 mark]

GO ON TO THE NEXT PAGE

(iii) In the space below, sketch graphs to show how the graph in Figure 3 will change if the material is

(a) Glass (b) Rubber

[2 marks]

(b) Figure 4 shows a 0.5 kg mass on a steel wire 1 m long and 2×10^{-3} m in diameter (Young modulus = 2×10^{11} Pa) being whirled in a vertical circle. The mass is at its lowest position and its velocity at this point is 38 m s^{-1}. The breaking stress of the wire is 7.2×10^{8} N m^{-2}.

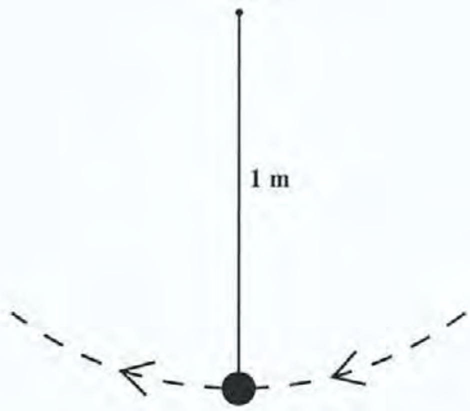


Figure 4

(i) On Figure 4 show the forces acting on the mass. **[2 marks]**

(ii) At the LOWEST point, calculate

a) the tension in the wire

[2 marks]

b) the stress experienced by the wire

[2 marks]

c) the extension of the wire.

[3 marks]

(c) Explain whether or not the wire breaks at this point.

___

___

___

[1 mark]

Total 15 marks

NOTHING HAS BEEN OMITTED

SECTION B

Attempt ALL questions.

You MUST write your answers in the answer booklet provided.

4. (a) Whilst doing an experiment on the stretching of a thin wire (diameter less than 0.5 mm) a student is required to measure its diameter. Describe how the diameter of the wire could be measured accurately. **[3 marks]**

(b) Discuss, using examples, the difference between precision and accuracy in physical measurement. **[4 marks]**

(c) When a liquid is boiled using an electrical heater the mass of liquid evaporated, m, is related to the power of the heater, P, and the elapsed time, t, by the equation $Pt = mL$. The specific latent heat, L, may be determined if the other quantities are measured. Table 2 shows the results of such an experiment.

TABLE 2

Power of heater	54 ± 2 W
Mass of liquid evaporated	$(9.9 \pm 0.1) \times 10^{-3}$ kg
Time elapsed	300 ± 2 s

Use this data to find the specific latent heat of the liquid, together with its uncertainty, and write the answer in the form $L = (x \pm y) \times 10^6$ J kg^{-1}, using an appropriate number of significant figures. **[8 marks]**

Total 15 marks

5. (a) A piece of perspex is placed in a ripple tank to make the water shallower, see Figure 5 (a).

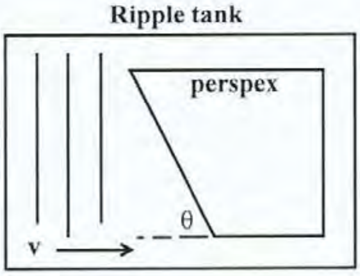


Figure 5 (a)

As the waves cross the front of the perspex, which is at an angle θ to the direction of propagation, they slow down. With the aid of a diagram, explain what happens to the waves. What is this phenomenon called? **[3 marks]**

(b) In an experiment with water waves in a ripple tank, a variable frequency a.c. source was used to vibrate a dipper so that it produced ripples on the water surface. The wavelength, λ, and wave speed, v, of the ripples were measured for various dipper frequencies.

The graph in Figure 5 (b) shows the variation of wave speed, v, with wavelength, λ, for ripples up to a wavelength of 8 mm.

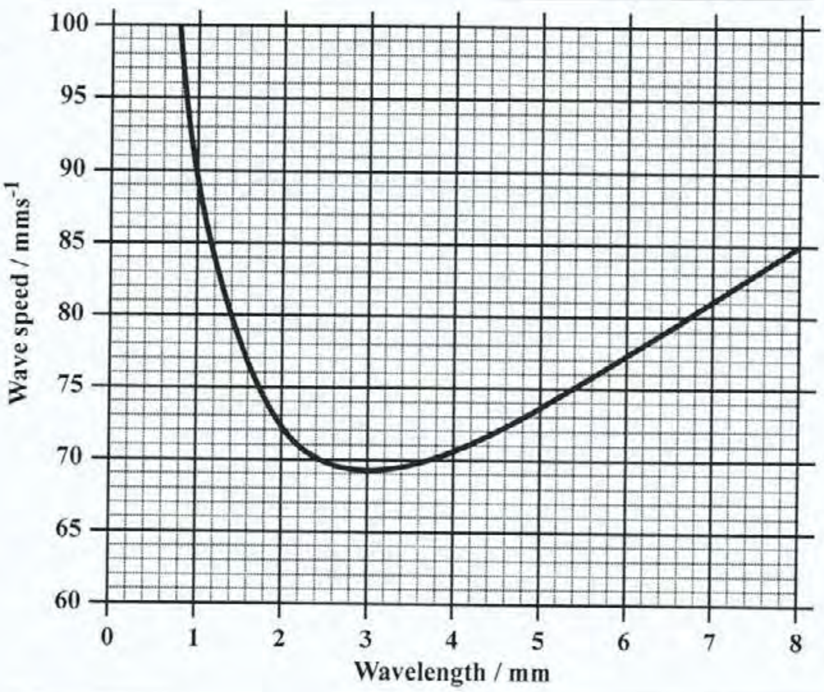


Figure 5 (b)

(i) By how much does the frequency decrease when the wavelength is changed from 3 mm to 8 mm? **[2 marks]**

(ii) With water of the depth used in the experiment, it can be shown that the speed of the ripples of **wavelength less than 2.0 mm** is given by

$$v^2 = \frac{k}{\lambda} + c$$

where k and c are constants and v is measured in mm s^{-1}.

a) Take readings from the graph and draw a suitable table of values.

b) Using the graph paper **provided on the insert**, plot a straight line graph to test the relationship.

c) Use your graph to determine the value of k. **[10 marks]**

Total 15 marks

6. (a) A scientist is investigating the rate of conduction, P, of thermal energy through various thicknesses, x, of the material to be used for the walls of a supermarket cold room. The graph in Figure 6 shows the results for various samples of the material, each with an area $0.25\ m^2$, for fixed inside and outside temperatures of -5 °C and 30 °C respectively.

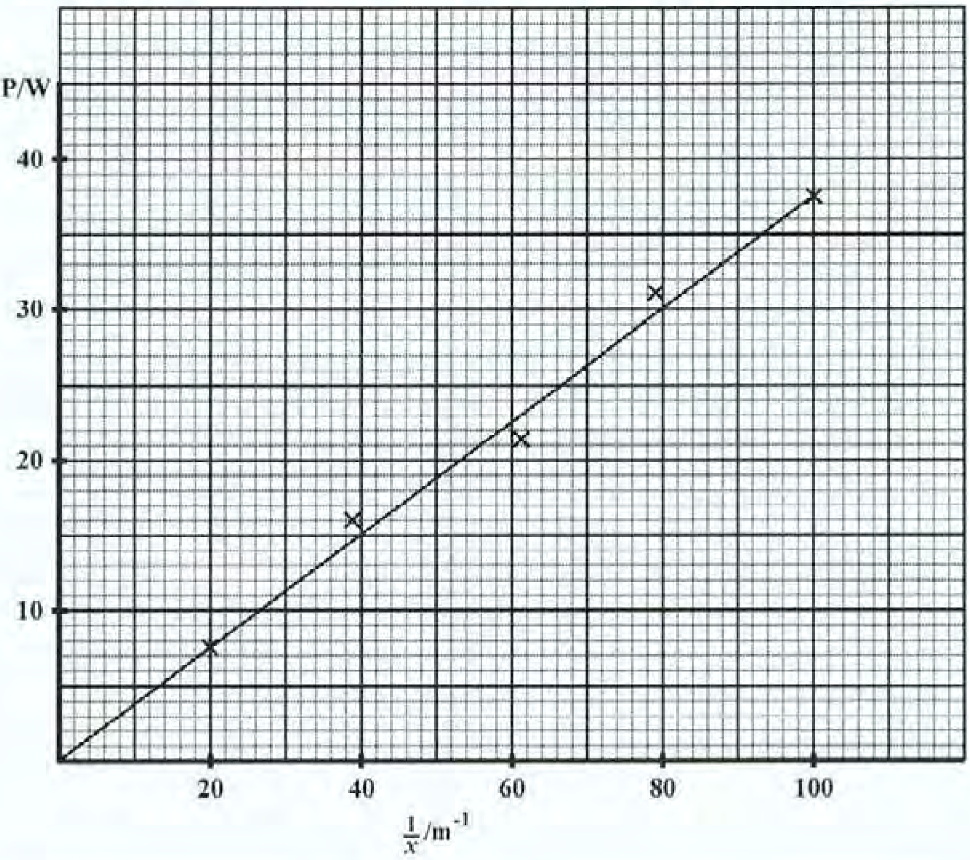


Figure 6

(i) Write a formula relating P to the inside and outside temperatures of the material, θ_1 and θ_2, and the thickness, x. **[1 mark]**

(ii) Use the graph to find the rate of flow of thermal energy when $x = 2.5$ cm and when $x = 4.5$ cm. **[5 marks]**

(iii) Use the gradient of the graph to find the thermal conductivity of the material. **[3 marks]**

(iv) Sketch the graph which would have been obtained if P were plotted against x instead of $\frac{1}{x}$. **[2 marks]**

(b) A packer working in a supermarket goes into the cold room where the temperature is -5 °C. If the man's surface area is about $2\ m^2$, estimate the net rate of heat loss from his body after just entering the room from outside where the temperature is 30 °C. **[4 marks]**

Total 15 marks

END OF TEST

FORM TP 2008246

TEST CODE **22138020**

MAY/JUNE 2008

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS – UNIT 1 - PAPER 02

Insert for Question 5 (b)

Registration Number ....

Centre Number ....

Candidate's Number ....

TO BE ATTACHED TO YOUR ANSWER BOOKLET

TEST CODE **02238020**

FORM TP 2008248

MAY/JUNE 2008

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 02 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **SIX** questions.
2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.
3. Section B consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the separate answer booklet provided.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

NOTHING HAS BEEN OMITTED

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
Elementary charge	e	=	1.60×10^{-19} C
Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Attempt ALL questions.

You MUST write your answers in this answer booklet.

1. When a capacitor discharges through a resistor its current at any instant is given by the equation:

$$I = I_o e^{-t/RC}$$

Using the circuit shown in Figure 1, a student collected data to plot a linear graph from this function.

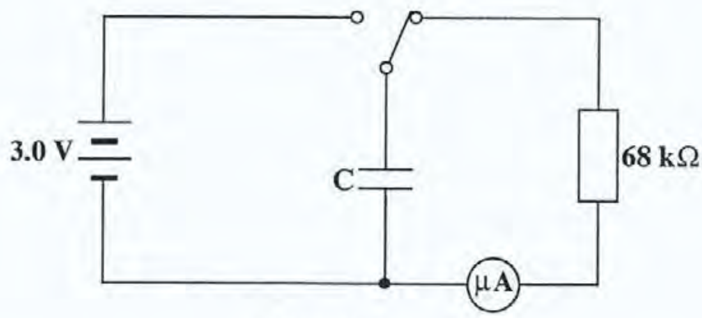


Figure 1

(a) In the space below write a suitable linear equation and then complete the table so that the straight line graph may be plotted. (Note that there is no need to convert the μA to amperes.) **[3 marks]**

Equation: ____

t/s	I/μA	ln (I/μA)
20	36	
40	30	
60	25	
80	20	
100	18	
120	15	
140	12	

(b) Use the student's results to plot on page 5 the required linear graph. **[5 marks]**

(c) Use the graph to find

(i) the value of the current at time $t = 0$

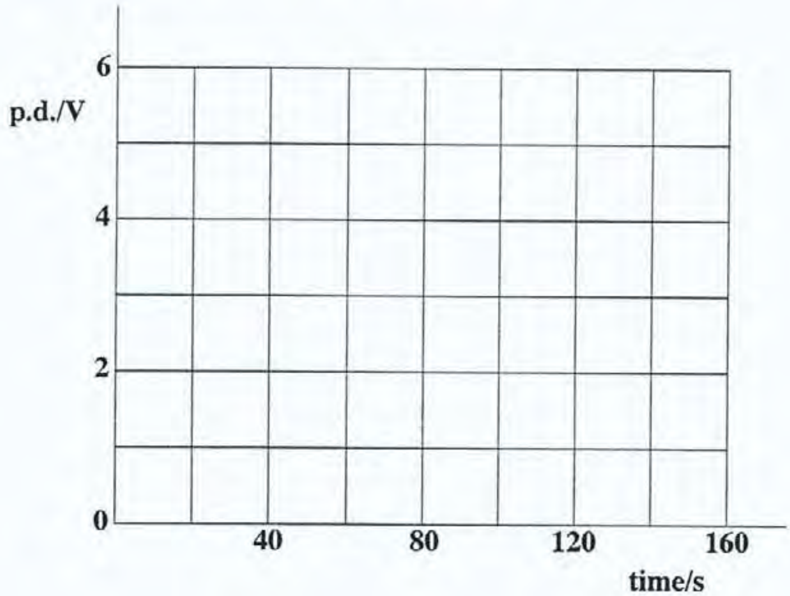
____

____

(ii) the time constant for the discharge.

[4 marks]

(d) (i) On the grid below sketch a graph to show how the potential difference (p.d.) across the capacitor varies with time during this discharge.



(ii) Write an equation for this voltage change using the actual values for the constants in it.

Equation: ____

____

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

2. (a) You are provided with a chip which has four NAND gates (a quad-NAND). Draw diagrams to show how the following logic gates might be constructed using (parts of) this chip.

(i) a NOT gate

(ii) an AND gate

(iii) an OR gate

[3 marks]

(b) (i) Complete the truth table below for the circuit shown in Figure 2.

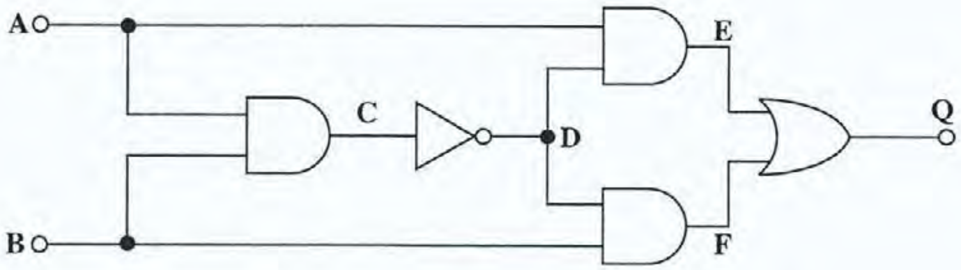


Figure 2

A	B	C	D	E	F	Q
0	0					
0	1					
1	0					
1	1					

[4 marks]

(ii) Replace all of the components in the circuit Figure 2 with NAND gates (Step 1) and then minimise the number of gates so that the circuit could be made using a single quad-NAND chip (Step 2).

Step 1:

Step 2:

[4 marks]

(c) Draw a diagram showing the construction of a bistable (or flip-flop) from two NAND gates and explain, with the aid of a sequential truth table, how it could operate as an electronic latch. I_1 and I_2 are the inputs on the flip-flop; Q and $\overline{Q}$ are the two outputs.

Sequential truth table:

#	I_1	I_2	Q	$\overline{Q}$
1	0	1		
2	1	1		
3	0	1		
4	1	0		
5	1	1		
6	1	0		

[4 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

3. (a) Figure 3a shows how the current in the photocell (Figure 3b) varies with the applied voltage.

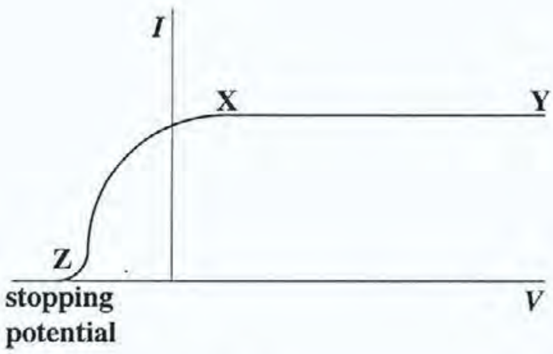


Figure 3a

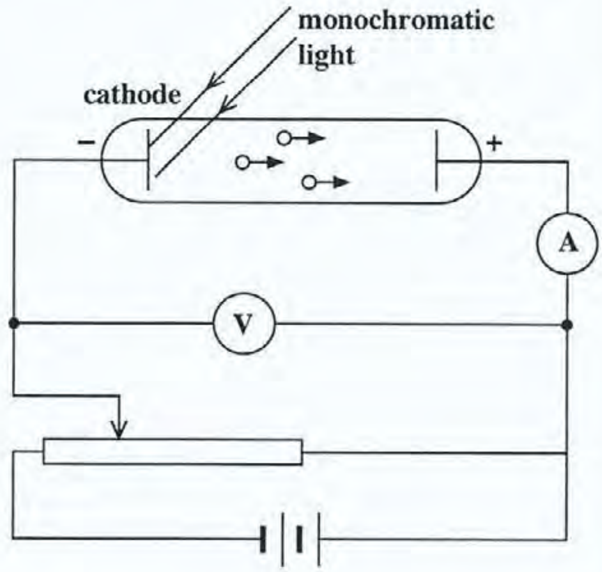


Figure 3b

(i) Add a curve to the graph in Figure 3a to show the effect of increasing the intensity of the light. LABEL the curve A. **[1 mark]**

(ii) Add another curve, labelled B, to show the expected result if radiation with a shorter wavelength were used. **[1 mark]**

(iii) Explain why the current stays constant between X and Y on the graph.

____

____

____

[2 marks]

(iv) Explain why the current decreases when the voltage across the tube is reversed (region XZ in Figure 3a).

____

____

____

____

[1 mark]

(v) How can the stopping potential be used to calculate the maximum kinetic energy of the photoelectrons?

____

[1 mark]

(b) The relationship between the maximum kinetic energy, E_{max}, of the electrons and the frequency of the incident radiation is given by the equation $hf = E_{max} + \Phi$.

(i) By plotting a suitable graph on the grid shown on page 12, using the data in the table below, determine a value for the Planck's constant h.

E_{max} / J x 10^{-19}	1.3	1.8	2.2	2.9	3.5	4.1
f / Hz x 10^{14}	7.5	8.4	9.0	10.2	11.0	11.7

Calculations

[7 marks]

(ii) Calculate the value of the work function for this photocathode.

[2 marks]

Total 15 marks

SECTION B

Attempt ALL questions.

You MUST write your answers in the answer booklet provided.

4. (a) Define magnetic flux and state Lenz's law. **[2 marks]**

(b) Figure 4 (a) shows a metal ring placed on top of a large coil, with an iron core threading the centre of the ring and the coil. A current is suddenly started in the coil and the ring jumps several centimetres into the air.

(i) Explain why the ring jumps into the air.

(ii) Describe and explain the motion of the ring, if any, when a slot is cut into the ring as shown in Figure 4(b).

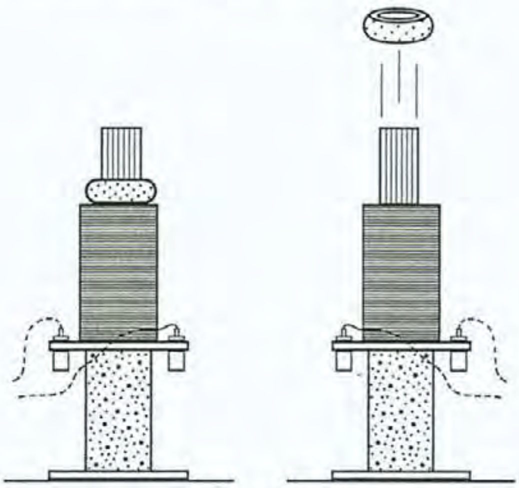


Figure 4(a)

Figure 4(b)

[4 marks]

(c) Figure 5 shows a circular coil of 150 turns, each of diameter 0.1 m which rotates 25 times each second about a diameter between the poles of a permanent magnet. The magnet produces a uniform magnetic field of flux density 4.0×10^{-4} T. At $t = 0$, the coil is in the position shown.

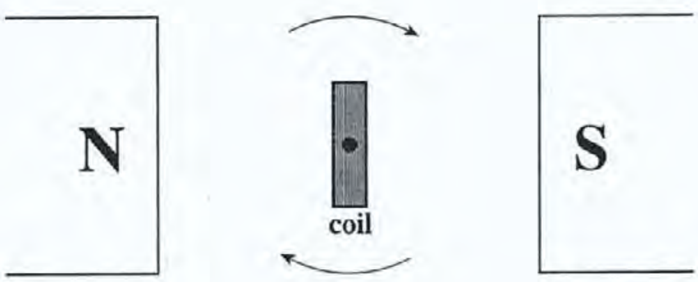


Figure 5

(i) Calculate the total magnetic flux Φ through the coil at time $t = 0$

(ii) Given that the rate of change of total flux at any time t is equal to $2\pi f \Phi \sin 2\pi ft$ (f is the frequency of rotation) find

a) the maximum instantaneous value of the induced e.m.f. in the coil

b) the r.m.s. value of the e.m.f. induced in the coil.

(iii) If the coil were fixed and the magnet were rotated at the same rate in the same direction, what difference would this make to the induced e.m.f?

[9 marks]

Total 15 marks

5. (a) Figure 6 shows an inverting amplifier.

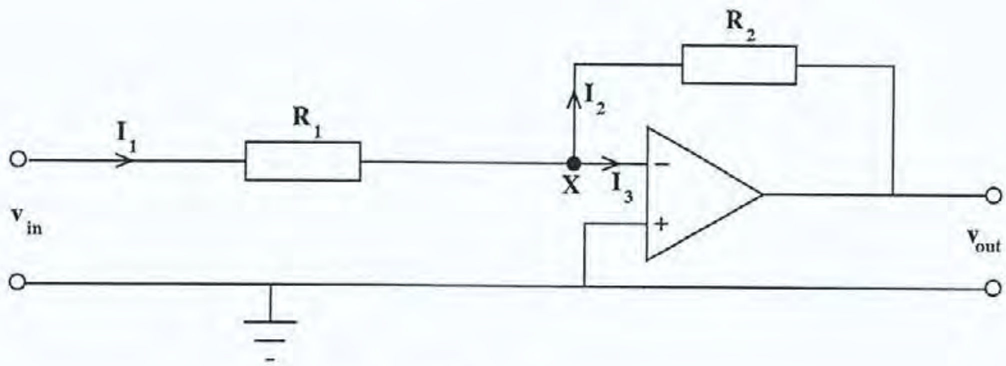


Figure 6

Derive the equation for the gain of an inverting amplifier (Figure 6)

$$A = -R_2 / R_1$$

where R_2 is the value of the feedback resistance and R_1 is the input resistance.

In your answer remember to state clearly TWO assumptions which you need to make about the properties of the operational amplifier used. **[5 marks]**

(b) To test how well this equation works in a practical situation the following data were collected by varying the input resistance whilst keeping the feedback resistance R_2 constant. The resistors used for R_1 had a tolerance of ± 1 %.

R_1/kΩ	10	15	20	40	50	75
A	99.7	66.9	49.8	25.1	20.0	13.5

By plotting a suitable graph find out whether the formula in part (a) applies to this situation. Remember to write a concise summary which includes the reasoning for your conclusion. **[10 marks]**

Total 15 marks

GO ON TO THE NEXT PAGE

FORM TP 2008248 TEST CODE **02238020**

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS – UNIT 02 - Paper 02

Insert for Question 5 (b)

Registration Number ....

Centre Number ....

Candidate's Number ....

TO BE ATTACHED TO YOUR ANSWER BOOKLET

6. (a) (i) Explain what is meant by the 'binding energy of the nucleus'.

(ii) Calculate the binding energy per nucleon (in joules) for an α-particle (helium-4 nucleus).

(iii) The binding energy per nucleon of helium-4 is much higher than that of other elements near to it in the periodic table. Comment on the significance of this fact.

[7 marks]

(b) Radon is a radioactive gas which emits α-particles. The activity of a sample of this gas is found to be 4 500 Bq at a particular time

(i) Write an equation for the decay of radon given that a radon nucleus (Rn) has 86 protons and 136 neutrons. The daughter product is an isotope of polonium (Po).

(ii) Calculate a value for the number of radon atoms present at the particular instant if the half-life of the radon is 55 s.

(iii) The energy released in the decay of one radon nucleus is 6.3 MeV. Find the rate of energy release (in watts) for the sample above with an activity of 4 500 Bq.

[8 marks]

[Data: nuclear mass of $^{4}_{2}He = 4.00150$ u

nuclear mass of $^{1}_{0}\mathrm{H} = 1.00728$ u (proton)

mass of $^{1}_{0}\mathrm{n} = 1.00867$ u (neutron)]

Total 15 marks

END OF TEST

TEST CODE **22238020**

FORM TP 2008248

MAY/JUNE 2008

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **SIX** questions.
2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in this answer booklet.
3. Section B consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the separate answer booklet provided.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

NOTHING HAS BEEN OMITTED.

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
Elementary charge	e	=	1.60×10^{-19} C
The Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Answer ALL questions.

You MUST write your answers in this answer booklet.

1. (a) (i) With the aid of a diagram explain the meaning of the term 'magnetic flux'.

[2 marks]

(ii) How is the unit of magnetic flux density related to the tesla?

[1 mark]

(iii) State Faraday's law of electromagnetic induction.

[1 mark]

(b) Figure 1 shows a coil with 16 turns which is wound on top of a solenoid with a cross-sectional area of 50 cm^2. An a.c. current through the solenoid produces a peak magnetic field of 7.5 mT which is changing at a rate of 500 Hz.

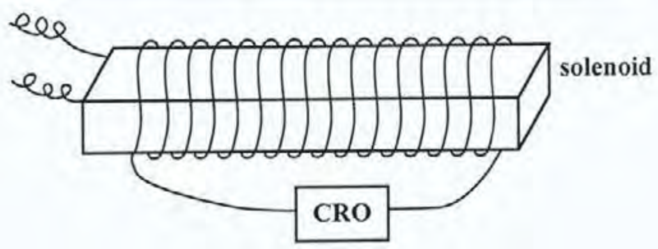


Figure 1

(i) Calculate the MAXIMUM value of the TOTAL flux linkage through the 16 turn coil.

[3 marks]

(ii) Find the peak value of the e.m.f. induced in the coil, given that the equation for the variation of the flux linkage is $\Phi = \Phi_o \sin 2 \pi ft$.

[2 marks]

(iii) Figure 2 (a) shows the screen of the cathode ray oscilloscope connected to the coil.

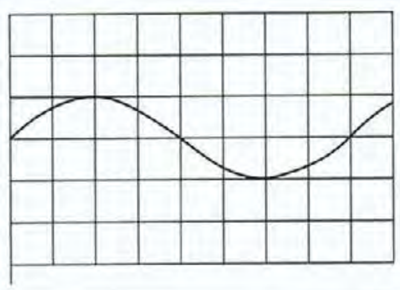


Figure 2 (a)

Show on Figure 2 (b) the c.r.o. trace you would expect if the number of turns wrapped around the solenoid was increased to 32.

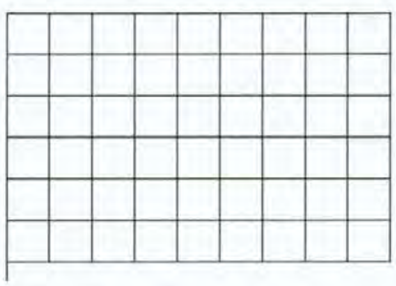


Figure 2 (b)

[2 marks]

On the third screen (Figure 2 (c)) show the effect of changing the frequency of the supply to the solenoid to 1000 Hz while **all other** factors remain constant.

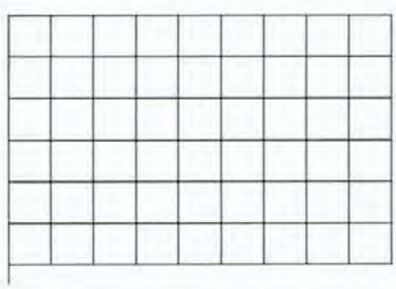


Figure 2 (c)

[2 marks]

(iv) Describe briefly how you could show that the induced e.m.f depends on the area of the coil.

____

____

____

____

[2 marks]

Total 15 marks

2. (a) The circuit diagram in Figure 3, shows an operational amplifier connected as a non-inverting amplifier.

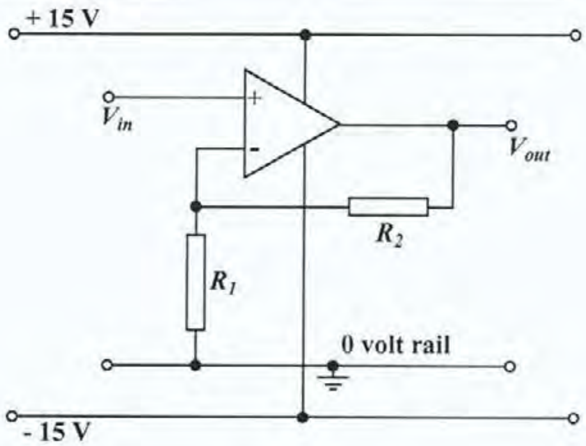


Figure 3. Operational amplifier connected as a non-inverting amplifier

(i) Suggest a pair of values for the resistors, R_1 and R_2, if the amplifier is to have a gain of +10.

R_1 = ____________________ kΩ R_2 = ____________________ kΩ

[2 marks]

(ii) What extra equipment would be needed to obtain data to plot the amplifier's transfer characteristic (graph of V_{out} vs V_{in})? Show on Figure 3 how these components would be connected.

____

____

[4 marks]

GO ON TO THE NEXT PAGE

(b) (i) Use the data in Table 1 to plot, on the grid on page 9, the transfer characteristic for a non-inverting amplifier similar to the one in part (a) on page 7.

TABLE 1

V_{in}/V	V_{out}/V	V_{in}/V	V_{out}/V
3.00	12.90	0.18	1.74
2.60	12.90	–0.59	–5.82
2.30	12.90	–0.98	–9.72
1.90	12.90	–1.18	–11.70
1.22	12.10	–1.60	–13.80
1.05	10.40	–1.90	–13.80
0.73	7.27	–2.60	–13.80
0.56	5.50	–3.00	–13.80

[5 marks]

(ii) From your graph determine the gain of the amplifier.

[2 marks]

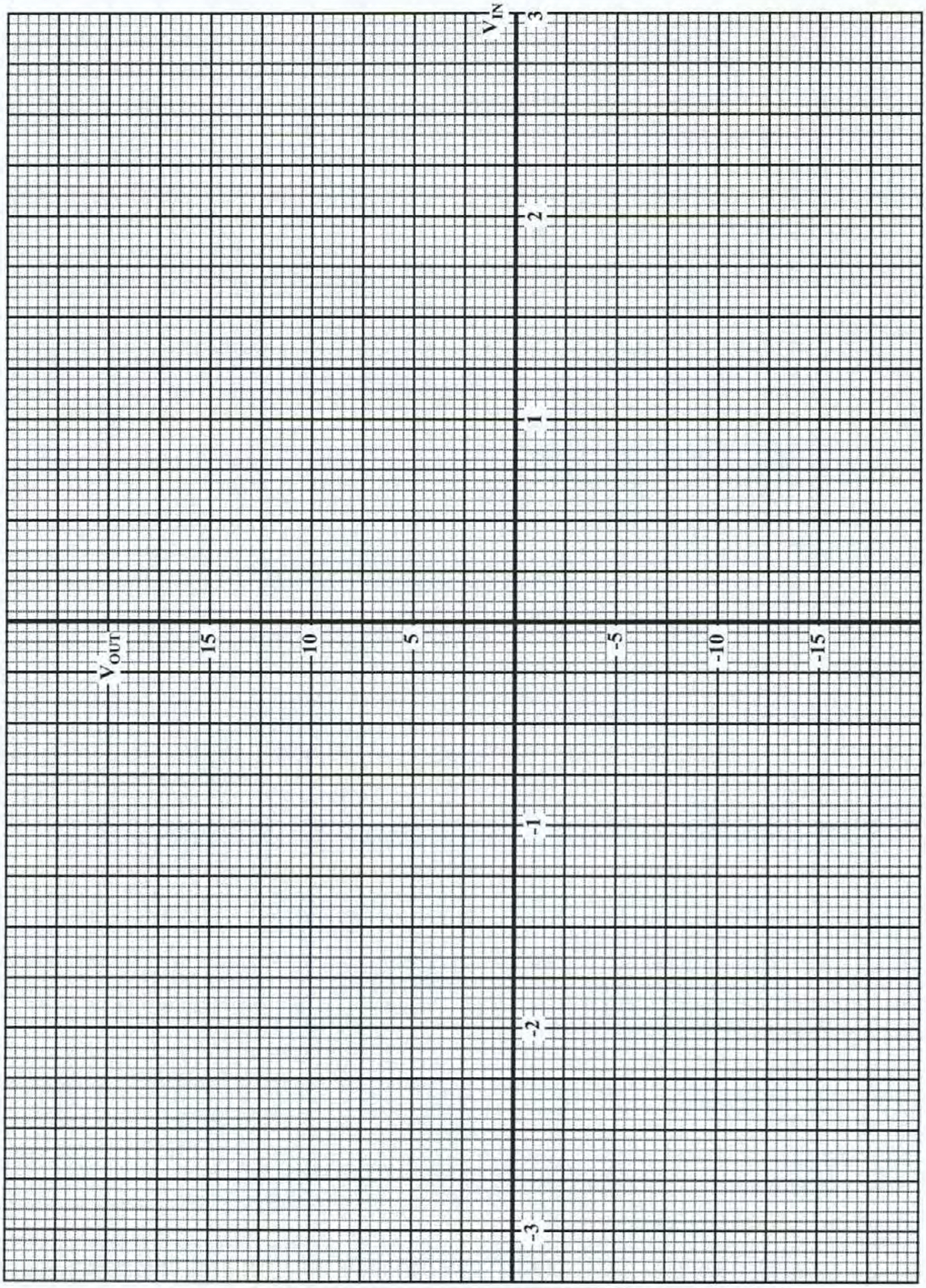
(iii) What is the range of possible input voltages if the amplifier is NOT to be saturated?

Maximum positive input = ______________________________

Maximum negative input = ______________________________

[2 marks]

Total 15 marks



V_{IN}
3
2
1
-1
-2
-3
V_{OUT}
15
10
5
-5
-10
-15

3. (a) Figure 4 shows an experimental arrangement used to investigate the photoelectric effect of a metal.

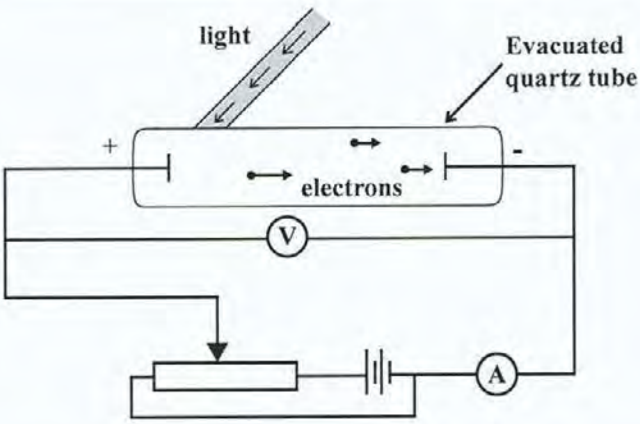


Figure 4. Experiment to investigate the photoelectric effect

The photoelectric equation may be written as $hf - \frac{1}{2}m_e v^2 = \phi$,
where h is Planck's constant, f is the frequency of the light used, ϕ is the work-function of the metal, m_e is the mass of the electron and v is the velocity of the emitted photoelectrons.

(i) Explain what is meant by the 'stopping potential'.

____

____

____

____

[1 mark]

(ii) With reference to Figure 4, explain how the stopping potential may be measured.

____

____

____

____

[2 marks]

(b) When a certain metal is illuminated with light of different wavelengths, the stopping potentials in Table 2 are observed.

TABLE 2

Wavelength, λ(nm)	Stopping potential (V_s)	Reciprocal Wavelength ($1/\lambda$) (m^{-1})
366	1.48	
405	1.15	
436	0.93	
492	0.62	
546	0.36	
579	0.24	

(i) Complete Table 2 by filling in the missing values of $\frac{1}{\lambda}$. **[1 mark]**

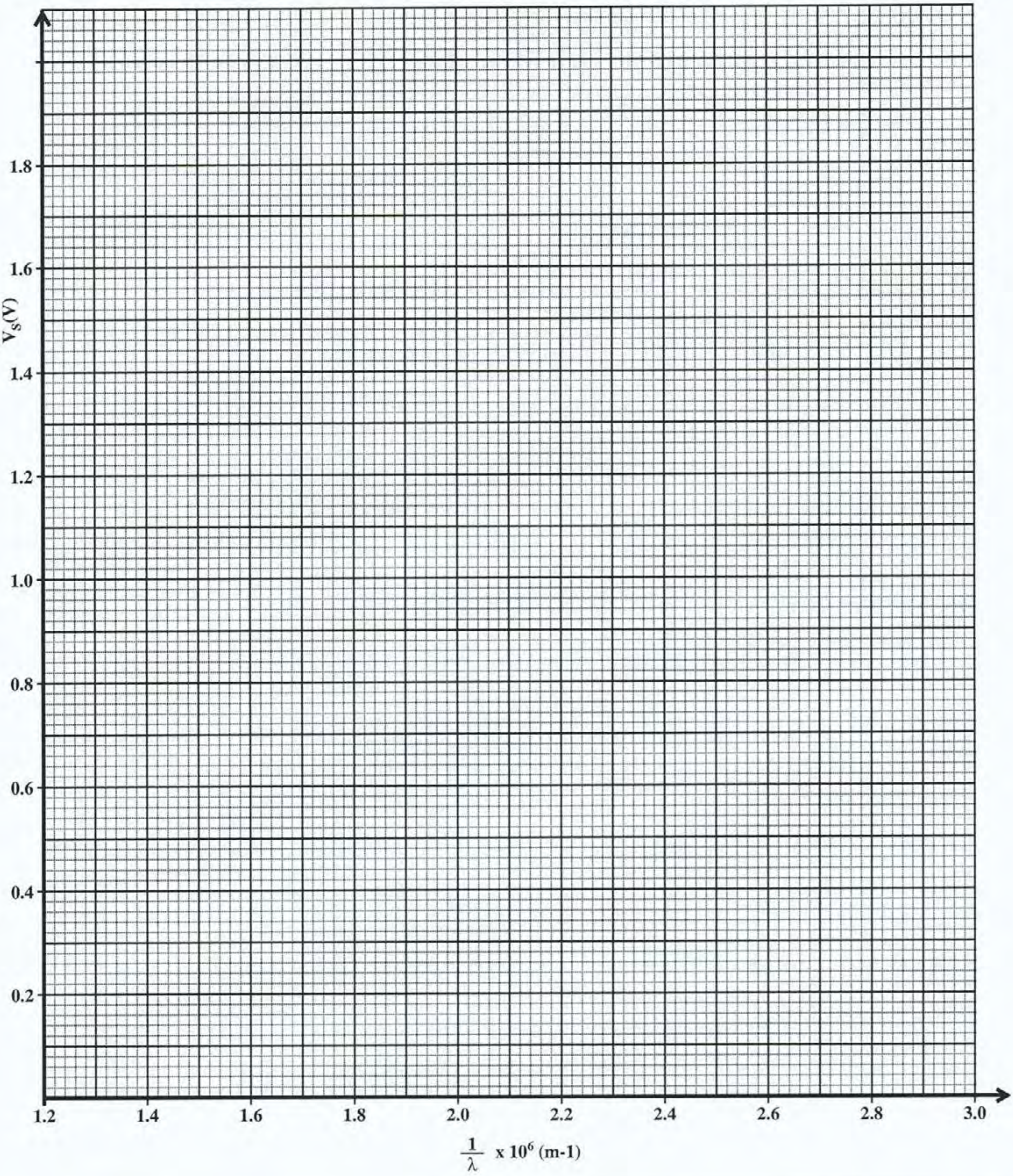
(ii) On the grid on page 12, plot a graph of stopping potential, V_s against $\frac{1}{\lambda}$.

[3 marks]

(iii) Use the graph to determine

a) Planck's constant

[4 marks]


V_S(V)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
$\frac{1}{\lambda}$ x 10^6 (m-1)

b) the cut-off wavelength, λ_0

[2 marks]

c) the work function of the metal.

[2 marks]

Total 15 marks

SECTION B

Answer ALL questions.

You MUST write your answers in the answer booklet provided.

4. (a) The graph in Figure 5 shows the variation with temperature of the resistance of a thermistor.

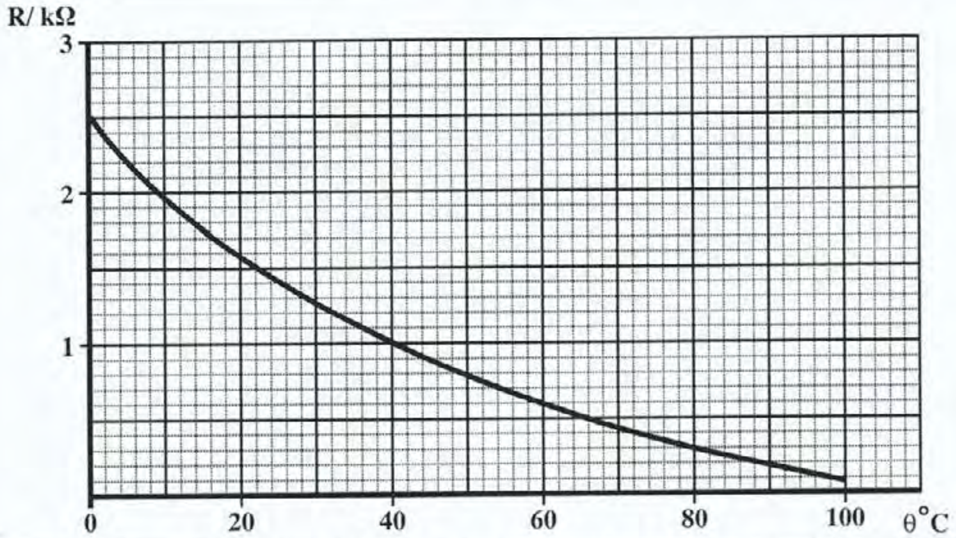


Figure 5. Variation of resistance with temperature for a thermistor

(i) a) Describe how values for the graph in Figure 5 could be obtained.

b) The diagram in Figure 6 shows a thermistor in a water bath. In your answer booklet copy Figure 6 and complete Figure 6 by drawing in the required circuit.

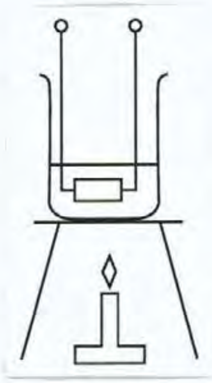


Figure 6

(ii) The thermistor is included in a resistor network as shown (Figure7).

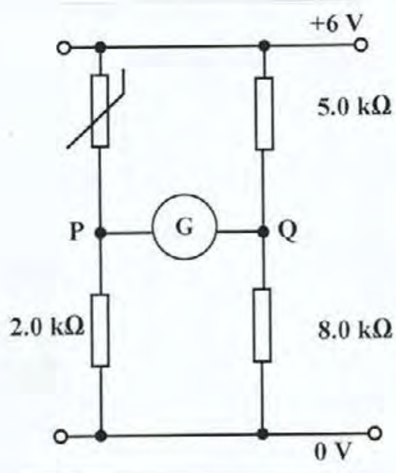


Figure 7

a) Find the potential at point Q.

b) At what thermistor temperature will the galvanometer read zero?

[11 marks]

(b) In the circuit shown in Figure 8 the batteries have negligible internal resistance. The currents supplied by the batteries are labelled x, y and z.

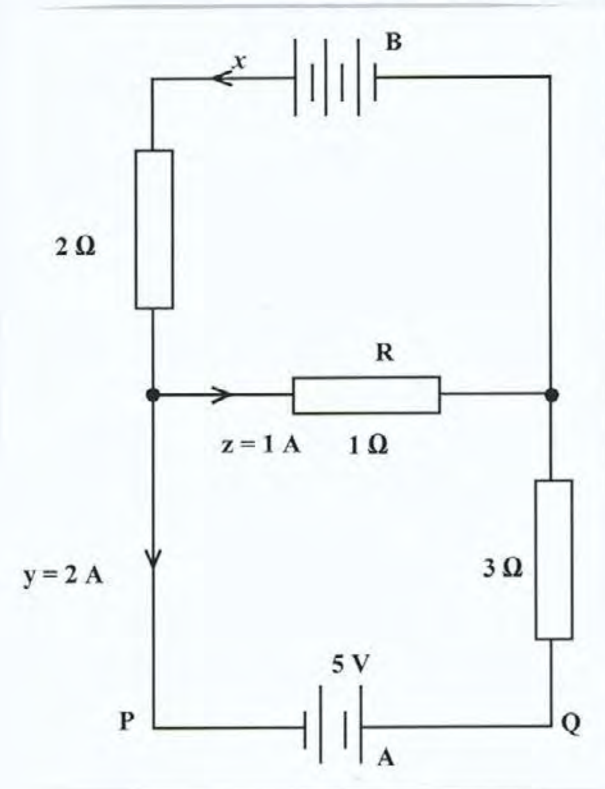


Figure 8

Given that current y is 2.0 A and current z is 1.0 A, calculate the e.m.f. of the battery labelled B. **[4 marks]**

Total 15 marks

5. (a) (i) Draw the truth tables for a NOR gate and a NAND gate.

(ii) Draw a circuit diagram to show how a NAND gate may be constructed from a number of NOR gates.

(iii) Redesign the circuit shown in Figure 9 so that it may be constructed using ONLY NOR gates. Reduce the circuit to the MINIMUM chip count.

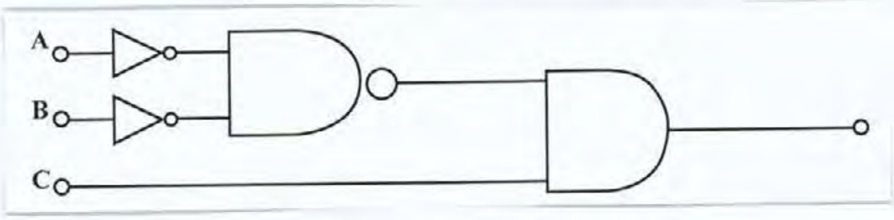


Figure 9

[8 marks]

(b) (i) Add the binary numbers 1011 and 101.

(ii) Discuss the difference between a half-adder and a full-adder in digital electronics.

(iii) Draw a diagram to show how a full adder is constructed from half-adders and give an example to explain its operation. **[7 marks]**

Total 15 marks

6. (a) (i) What is the evidence in Millikan's oil drop experiment for the quantization of charge.

(ii) Give TWO measures adopted by Millikan to improve accuracy in the oil drop experiment.

(iii) Explain how it is possible to change the charge on an oil droplet.

[5 marks]

(b) Figure 10 shows two plane parallel conducting plates 1.50×10^{-2} m apart, held horizontally, one above the other in air. The upper plate is maintained at a positive potential of 1.50×10^{3} V while the lower plate is earthed. A small oil drop of mass 9.80×10^{-15} kg remains stationary in the air between the plates. The density of the air is negligible in comparison with that of oil.

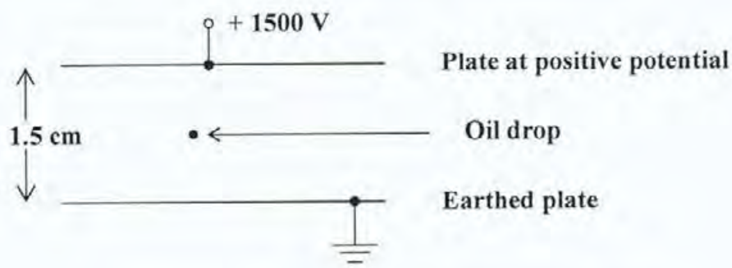


Figure 10

(i) Draw a free body diagram showing the forces acting on the oil drop.

(ii) Calculate

a) the charge on the oil drop

b) the number of electrons attached to the oil drop.

(c) The potential of the upper plate is suddenly changed to -1.50×10^{3}V. Determine the initial acceleration of the charged drop.

[10 marks]

Total 15 marks

END OF TEST

FORM TP 2009241

TEST CODE **02138032**

MAY/JUNE 2009

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 01 – Paper 03/2

ALTERNATIVE TO SBA

2 hours

Candidates are advised to use the first 15 minutes for reading through this paper carefully.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **THREE** questions. Candidates must attempt **ALL** questions.

2. The use of non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

1. The aim of this experiment is to plot a calibration curve for a thermistor.

The following apparatus is provided:

– Bunsen burner, tripod and gauze, beaker of water and stirring rod, thermistor, ammeter and voltmeter suitable for the thermistor chosen, switch, cells, crushed ice, spare beaker.

(a) (i) Set up the circuit as shown in Figure 1 with the thermistor in the beaker of water.

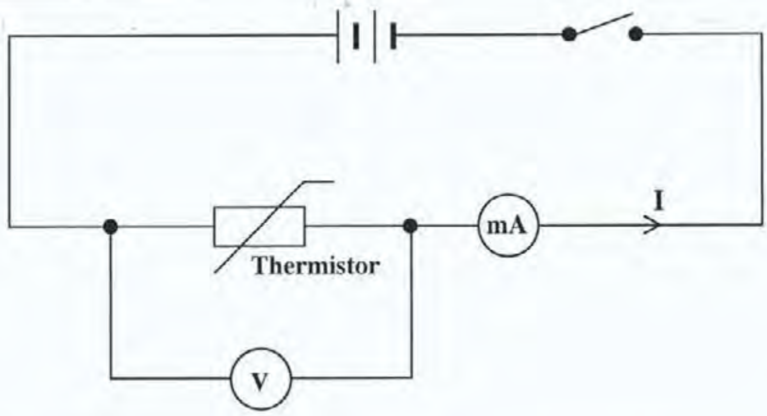


Figure 1: Circuit to measure the voltage across and the current through a thermistor

[2 marks]

(ii) Add ice to the beaker of water so that the water is as cold as possible. Measure the voltage, V, across the thermistor and the current, I, through the thermistor at various temperatures as the water is heated. Tabulate your results in the table below and complete the table by calculating the resistance (R).

Temperature (θ) / °C	**Current (I) / mA**	**Voltage (V) / V**	**Resistance (R) Ω**

[3 marks]

(iii) Use the data to plot a graph of Resistance, R, versus temperature, θ on page 3.

[5 marks]

(iv) Clearly state any precautions you took to ensure that accurate results were obtained.

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[1 mark]

(b) (i) Use the graph you have plotted to determine the temperature at which the resistance is one half of the value at room temperature.

[2 marks]

(ii) Calculate the value of this temperature on the empirical centigrade scale. Use the formula

$$\theta = \left(\frac{R_\theta - R_o}{R_{100} - R_o} \right) \times 100$$

[3 marks]

Total 16 marks

GO ON TO THE NEXT PAGE

2. The formula for the period of oscillation of a mass hung from a spring is $T = 2\pi\sqrt{\frac{m}{k}}$.

Using this equation, describe how you would test the hypothesis that two identical springs in series (end to end) have a force constant, K^*, which is half that of a single spring i.e. $K^* = \frac{1}{2}k$.

List of Apparatus:

[4 marks]

Procedure:

[8 marks]

Manipulation of Results and Calculations:

[3 marks]

How would you expect the period of oscillation to change when the mass hanging from a spring is doubled?

[1 mark]

Total 16 marks

3. The aim of this experiment is to measure the viscosity (η) of a liquid. Figure 2 shows an experimental arrangement for measuring the fall of steel ball-bearings through a liquid.

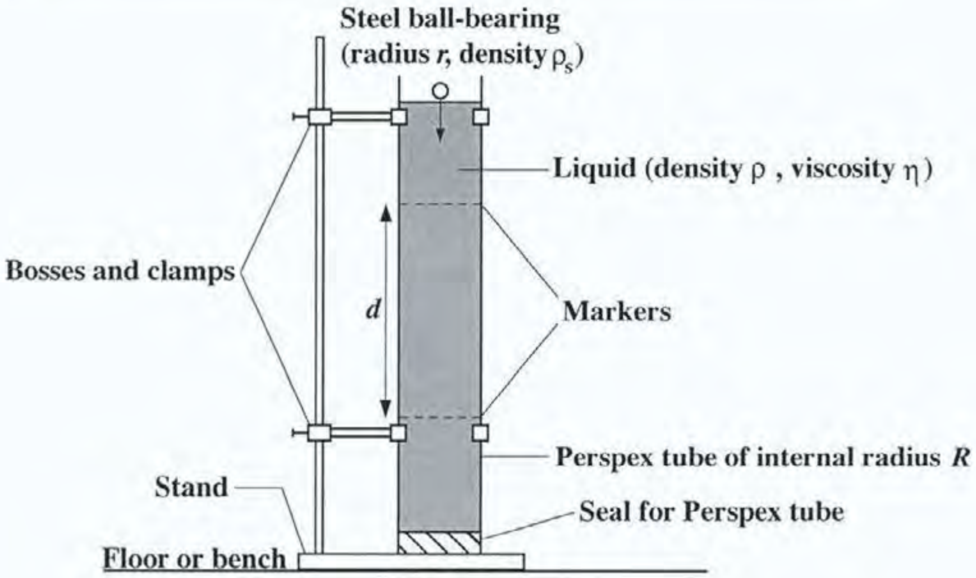

Figure 2: Experimental arrangement for measuring the fall of steel ball-bearings through a liquid

Figure 3 shows the forces acting on a steel ball-bearing of radius r and mass m as it fall through the liquid of viscosity (η) at an acceleration a.

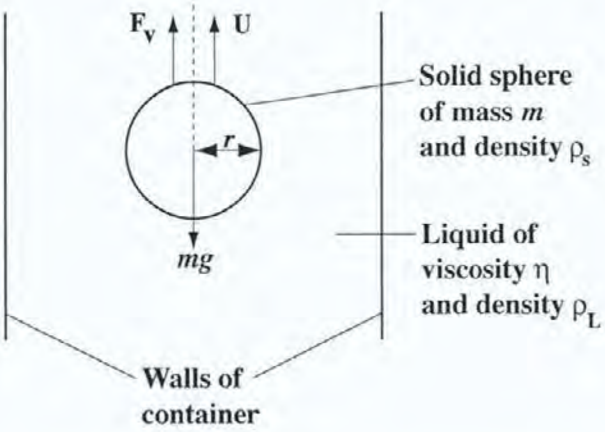

Figure 3: Forces acting on a sphere of radius r falling through a liquid of viscosity η

The following forces act on the sphere.

- Viscous force $F_v = kv = 6\pi\eta r v$.
- Upthrust U = weight of liquid displaced $= \frac{4}{3}\pi r^3 \rho_L g$
- Weight of the ball-bearing $= mg = \frac{4}{3}\pi r^3 \rho_S g$

Resultant force $= ma = mg - U - F_v$

On reaching the terminal velocity V_t, the acceleration is zero and the resultant force is zero.

Therefore $0 = mg - U - F_v$

For a ball-bearing of density ρ_S and a liquid of density ρ_L

$$0 = \frac{4}{3}\pi r^3 g\ \rho_S - \frac{4}{3}\pi r^3 g\,\rho_L - 6\pi\eta r v_t$$

$$0 = \frac{4}{3}\pi r^3 g\,(\rho_S - \rho_L) - 6\pi\eta r v_t$$

or $$v_t = \frac{2(\rho_S - \rho_L)\,g\,r^2}{9\eta}$$

Table 1 below shows the results obtained from one such experiment.

Diameter of ball-bearings (d) /mm	**Mass of ball-bearings (m) /g**	**Time (t) /s**	**Distance (d) /cm**	**Speed v_t (m s^{-1})**	**Radius (r) / mm**	**r^2**
3.38	0.11	5.311	50			
4.96	0.27	3.387	50			
4.75	0.44	2.601	50			
5.50	1.05	1.848	50			
4.24	0.85	3.33	50			

(a) Complete Table 1 by calculating V_t, r and r^2. **[2 marks]**

(b) On the grid on page 9 plot a graph of v_t vs r^2. **[6 marks]**

(c) Determine the gradient of your graph.

[4 marks]

GO ON TO THE NEXT PAGE

(d) Given that the density of the ball-bearing is 7.8 g cm^{-3}, the density of the liquid is 1.26 g cm^{-3} and the acceleration due to gravity is 9.81 m s^{-2}, calculate the viscosity η of the liquid.

[4 marks]

Total 16 marks

END OF TEST

TEST CODE **02238020**

FORM TP 2009243

MAY/JUNE 2009

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **SIX** questions.
2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.
3. Section B consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the separate answer booklet provided.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
	$\frac{1}{4\pi\varepsilon_0}$	=	9.0×10^{9} m F^{-1}
Elementary charge	e	=	1.60×10^{-19} C
Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Answer ALL questions.

You MUST write your answers in the spaces provided in this answer booklet.

1. (a) Sketch graphs to show the I – V characteristics of EACH of the following devices: (i) a metallic conductor at constant temperature, (ii) a filament bulb

(i) Metallic conductor

(ii) Filament bulb

[2 marks]

(b) It is desired to test the I – V characteristics of a diode to be used in a circuit. Below the "turn on" voltage the current, I, is related to the voltage, V, by the relation, $I = kV^n$ where k and n are constants for the particular diode.

(i) Draw a potential divider circuit that could be used to examine the I - V characteristics of the diode.

[2 marks]

(ii) Describe how the readings would be taken.

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[2 marks]

(c) Figure 1 shows the I - V characteristic that was obtained for a diode, operated at a temperature of 25°C.

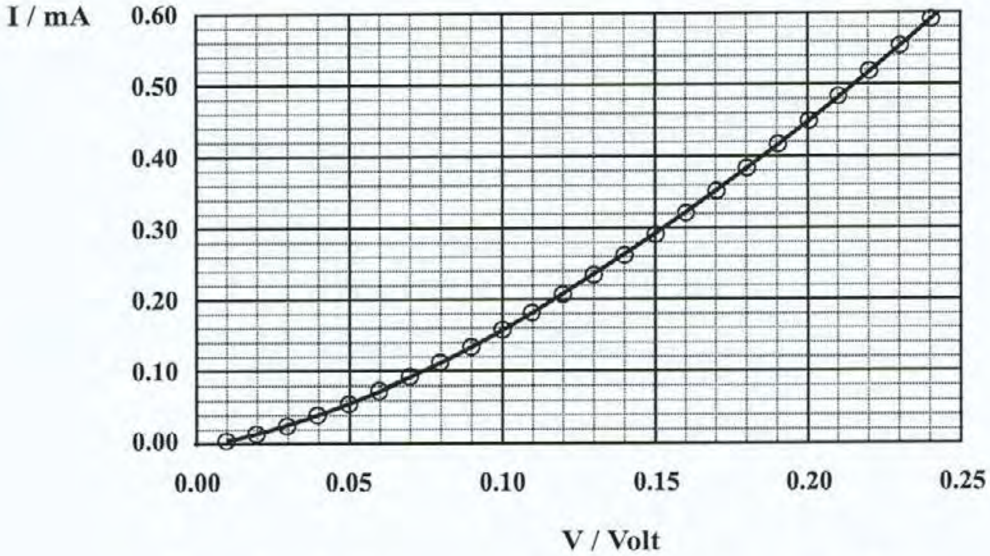


Figure 1 – I - V characteristic of a diode for small p.d.'s

(i) Use the data presented in Figure 1 to determine the value of n in the relation $I = kV^n$.

[3 marks]

(ii) Deduce the actual equation relating the current, I, to the voltage, V, for this diode.

[2 marks]

(iii) Calculate the d.c. resistance of the diode at I = 0.32 A.

[2 marks]

(iv) Suggest a better way of processing the data obtained in this experiment to determine the values of n and k.

[2 marks]

Total 15 marks

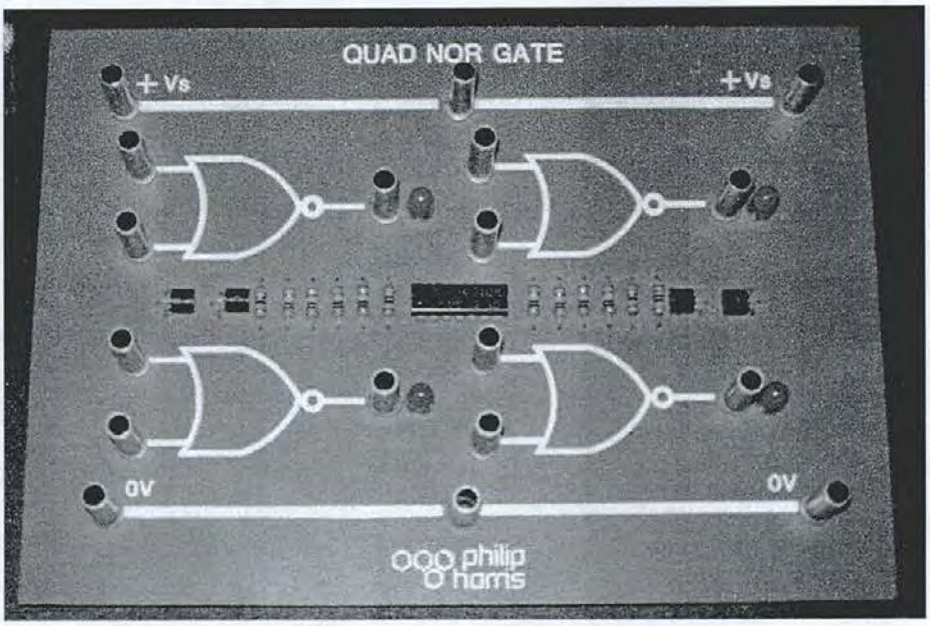
2. (a) (i) Complete the table to show the action of a NOR gate.

NOR truth table

A	B	OUT
0	0	
0	1	
1	0	
1	1	

[1 mark]

(ii) Draw a diagram to show how a NOR gate can be connected to function as a NOT gate. **[1 mark]**



(iii) The photograph above shows a circuit board with four NOR gates. Add connecting wires to the given diagram (Figure 2) to show how the NOR gates could be connected to form a NAND gate.

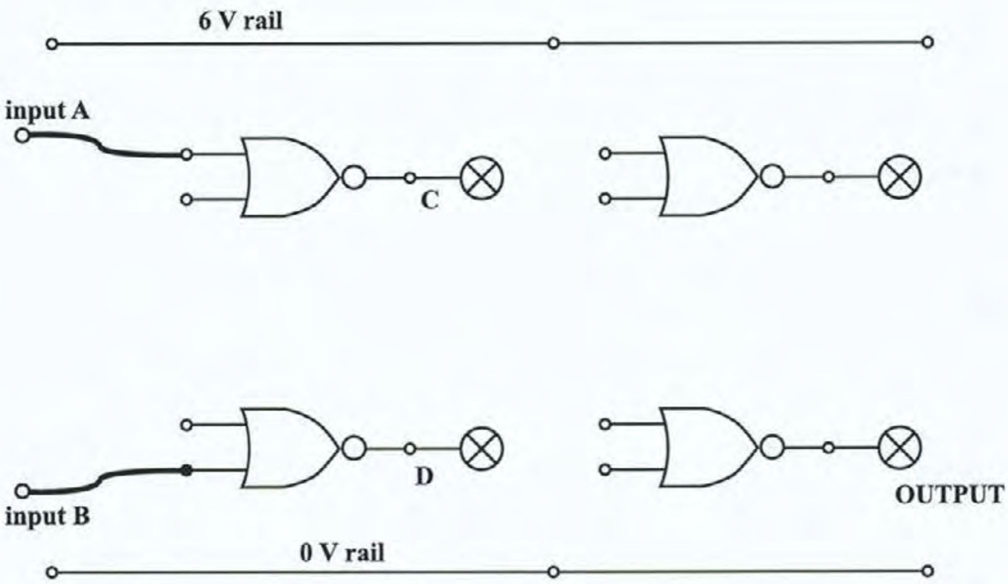


Figure 2: Quad NOR gate

[4 marks]

(b) Figure 3 shows a logic circuit designed to operate a lamp.

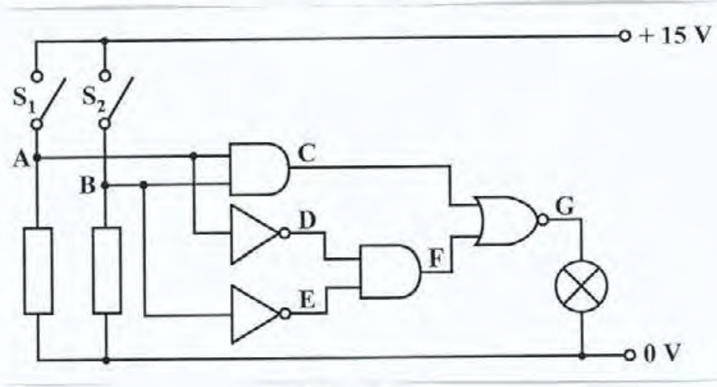


Figure 3

(i) Give the logic state of B when the switch S_2 is closed. ______

[1 mark]

(ii) Complete the truth table in Figure 4.

A	B	C	D	E	F	G
0	0					
0	1					
1	0					
1	1					

Figure 4

[5 marks]

(iii) What logic combination of S_1 and S_2 would cause the lamp to be ON?

______

______

[1 mark]

GO ON TO THE NEXT PAGE

(iv) Draw a logic circuit to show how NAND gates only may be used to carry out the SAME function as the circuit of Figure 3.

[2 marks]

Total 15 marks

3. (a) (i) Einstein's photoelectric equation can be written as $K_{max} = hf - \phi$. Clearly explain EACH term used in this equation.

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____

[3 marks]

(ii) Sketch a labelled graph of photocurrent versus applied voltage for two values of light intensity I_1 and I_2, where $I_2 > I_1$. Indicate **clearly** the stopping potential.

[2 marks]

GO ON TO THE NEXT PAGE

(b) The following data are found for photoemission from calcium:

Stopping potential, V_s / V	**Wavelength, λ / nm**	**Frequency, f / Hz**
1.93	253.6	
1.51	279.5	
0.97	313.0	
0.50	365.5	
0.13	405.1	

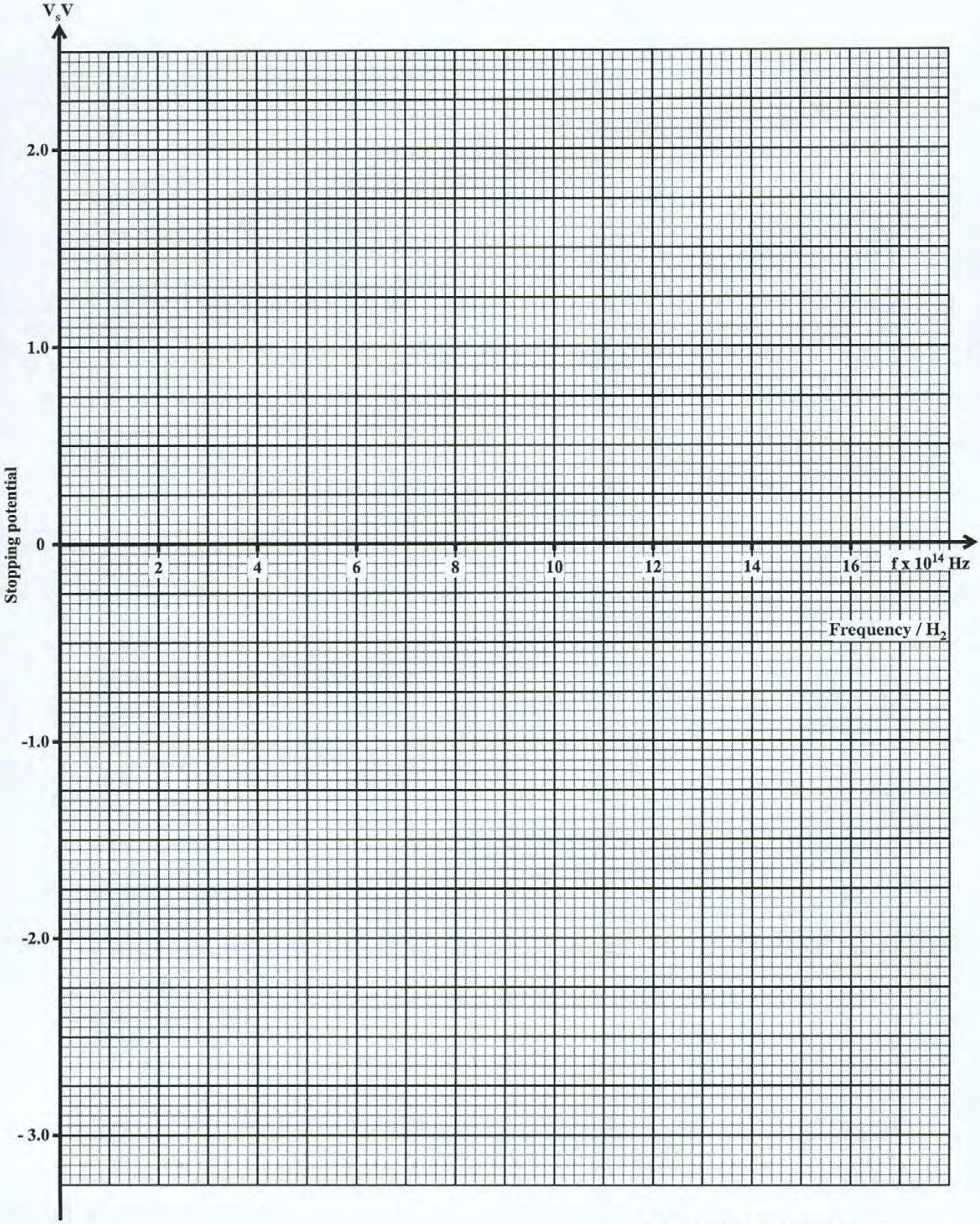
(i) Complete the table by filling in the values of frequency f. **[1 mark]**

(ii) On the grid on page 11, plot a graph of stopping potential V_s versus frequency f. Draw the BEST straight line through the points. **[3 marks]**

(iii) From your graph, determine

a) Planck's constant

[3 marks]



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b) the threshold frequency

[1 mark]

c) the work function of the metal.

[2 marks]

Total 15 marks

SECTION B

Answer ALL questions.

You MUST write your answers in the separate answer booklet provided.

4. (a) (i) Distinguish between 'magnetic flux density' and 'magnetic flux'.

(ii) State Faraday's law of electromagnetic induction.

(iii) State Lenz's law. **[4 marks]**

(b) Figure 5 shows a long solenoid which has a small copper disc mounted at its centre. The disc spins on an axle which lies along the axis of the solenoid. By means of brushes, one connected to the rim of the disc and the other connected to the axle, the millivoltmeter can display the e.m.f. generated.

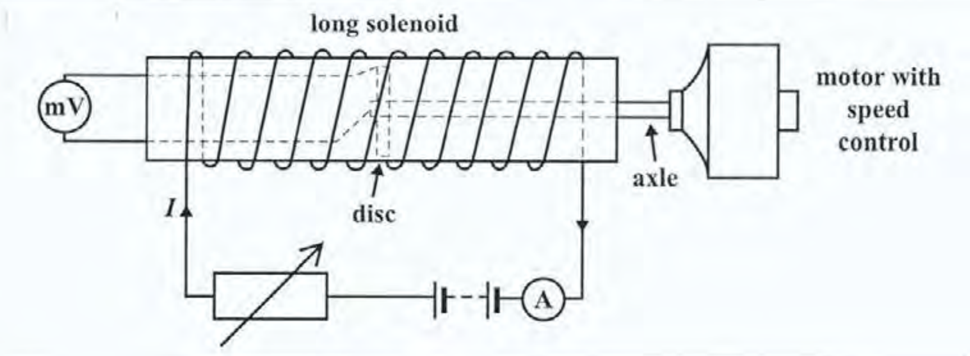

Figure 5

(i) Explain why an e.m.f. is generated between the axle and the rim of the disc when the disc rotates.

(ii) The disc has a diameter of 40 mm and rotates at 9.5 revolutions per second. The solenoid is 0.080 m long, has 160 000 turns, and carries a steady current of 5.0 mA. Calculate

a) the magnetic field within the solenoid

b) the magnetic flux cut every revolution

c) the potential difference maintained between the rim and the axle of the disc. **[8 marks]**

(c) The apparatus in Figure 5 could be used in an experiment to verify Faraday's law by changing the speed of the motor and measuring the corresponding e.m.f. Sketch a graph of the expected results and state how your conclusion would be made from the graph. Also state which factors must be held constant if the conclusion is to be valid. **[3 marks]**

Total 15 marks

5. Figure 6 shows the variation with frequency f of the voltage gain G, without feedback, of an ideal operational amplifier (op-amp).

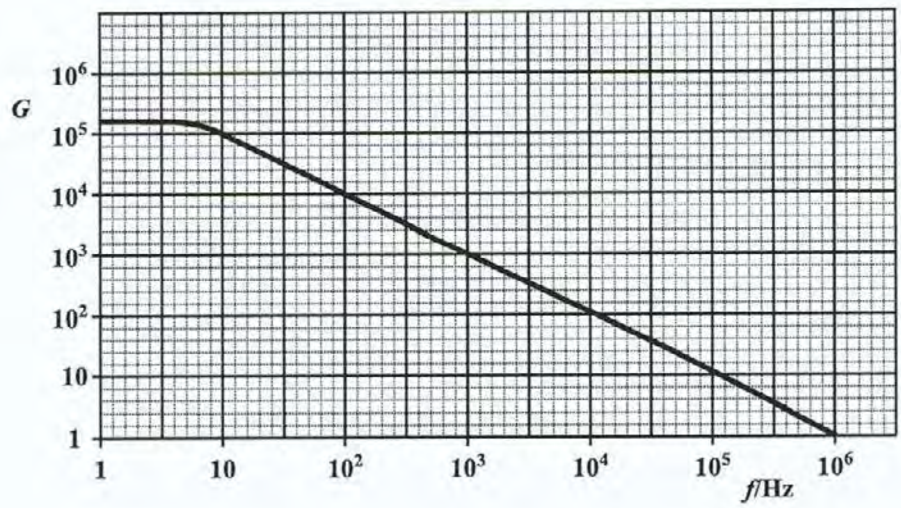

Figure 6

The op-amp is used in the amplifier circuit of Figure 7.

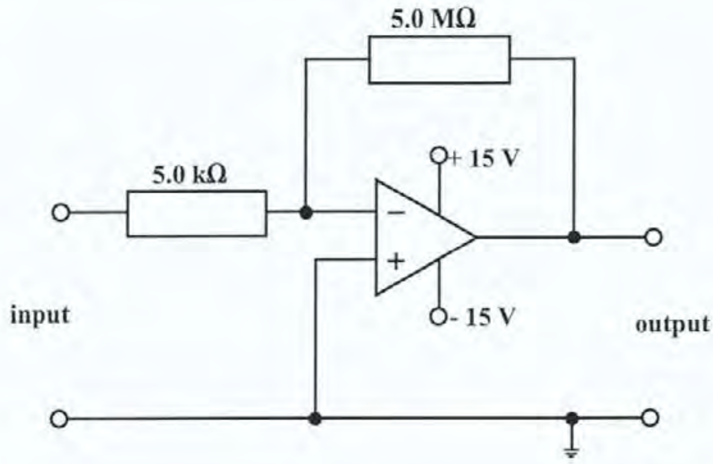

Figure 7

(a) (i) State the type of amplifier shown in Figure 6.

(ii) What is meant by 'negative feedback'?

(iii) Calculate the bandwidth of the amplifier. **[5 marks]**

(b) Calculate the peak output voltage for an input signal of peak value 0.01 V if the frequency is

(i) 500 Hz

(ii) 10 000 Hz **[4 marks]**

(c) The input of the amplifier in Figure 7 is connected to an audio frequency generator producing a signal like the one shown on the graph below. The amplifier is operated off a ±15 V supply.

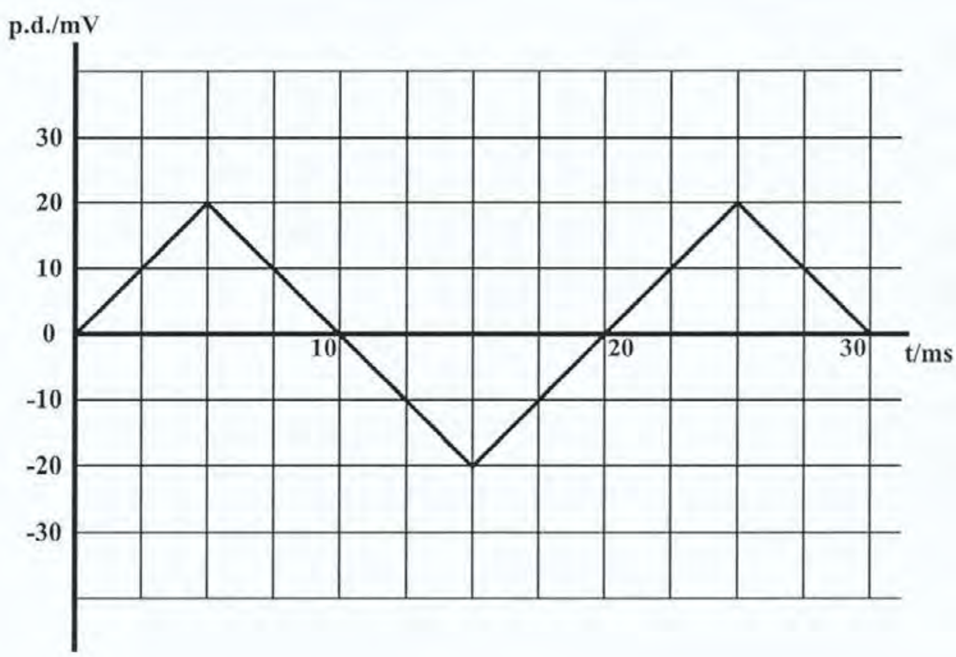

Figure 8

(i) What is the frequency of this signal?

(ii) Find the output of the amplifier when $t = 5$ ms.

(iii) Sketch a graph to show the shape of the output waveform from the amplifier. **[6 marks]**

Total 15 marks

6. (a) Explain the terms 'decay constant' (λ) and 'half life' ($T_{\frac{1}{2}}$).

Derive an equation relating these two quantities, starting with the decay equation $N = No\ e^{-\lambda t}$. **[5 marks]**

(b) Sodium 24 (atomic mass 24 g mol^{-1}) is a radioactive isotope that beta-decays with a half life of 15.0 hours.

For this isotope, calculate

(i) the decay constant in units of s^{-1}

(ii) the number of atoms in a 1.0 mg sample

(iii) the activity of a 1.0 mg pure sample. **[5 marks]**

(c) A small volume of solution, which contained the radioactive isotope sodium 24, had an activity of 1.2×10^4 disintegrations per minute when it was injected into the blood stream of a patient. After 30 hours the activity of 1.0 cm^3 of the blood was found to be 0.50 disintegrations per minute. Calculate the volume of blood in the patient. **[5 marks]**

Total 15 marks

END OF TEST

TEST CODE **02238032 – IS**

FORM TP 2009244 – IS

MAY/JUNE 2009

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 02 – Paper 03/2

ALTERNATIVE TO INTERNAL ASSESSMENT

02 JUNE 2009 (p.m.)

INSTRUCTIONS FOR SETTING UP THE ALTERNATIVE TO INTERNAL ASSESSMENT EXAMINATION

Question 1.

For EACH candidate:

- 1 5.0 Ω standard resistor
- 1 Galvanometer
- 1 Variable resistor (rheostat)
- Battery with terminals (2 V or 3 V would be suitable)
- 1 Switch
- 1.5 m of bare constantan wire swg 30, labelled Z
- Metre rule
- A Wheatstone metre bridge. (Alternatively a 1 m length of 28 swg constantan wire connected to two terminals fixed to a length of wood. A second metre rule should be fixed under the wire)
- 9 connecting wires
- Micrometer

- A "jockey" attached to a 1 m length of connecting wire

- The wires should be provided with suitable terminals so that candidates would be able to assemble the circuit conveniently. (But supervisors must NOT have the wires already connected in a circuit.)

Question 2.

Question 3.

END OF INSTRUCTIONS

TEST CODE **02138020**

FORM TP 2010233

MAY/JUNE 2010

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 1 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **SIX** questions.
2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.
3. Section B consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the space at the end of each question.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
Acceleration due to gravity	g	=	9.8 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water		=	1.00×10^{3} kg m^{-3}
Specific heat capacity of water		=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice		=	3.34×10^{5} J kg^{-1}
Specific latent heat of vaporization of water		=	2.26×10^{6} J kg^{-1}
Avogadro's constant	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan-Boltzmann's constant	s	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in free space	c	=	3.00×10^{8} m s^{-1}

NOTHING HAS BEEN OMITTED

SECTION A

Answer ALL questions in this section. Write your answers in the spaces provided in this answer booklet.

1. (a) Figure 1 shows a ball placed at the top of an inclined plane with a block rigidly fixed to the bottom of the plane.

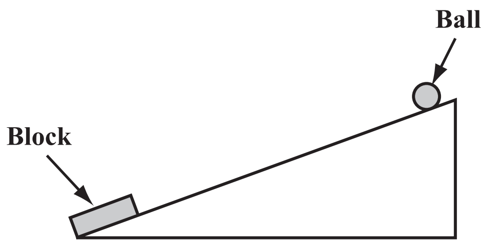

Figure 1

The ball of mass 0.60 kg is released from rest from the top of the plane and *v*, the velocity of the ball down the plane, is measured for various values of time *t*. Table 1 shows the variation of velocity with time.

Table 1

Velocity v/m s–1	Time, t /s	Velocity v/m s–1	Time, t /s
0	0	– 3.4	1.25
0.6	0.2	– 2.8	1.4
1.4	0.4	– 2.1	1.6
2.1	0.6	– 1.4	1.8
2.8	0.8	– 0.8	2.0
3.5	1.0	0	2.2
4.2	1.2		

(i) On the grid on page 5, plot a graph of velocity *v*, versus time *t*.

[4 marks]

(ii) Using your graph, describe qualitatively the motion of the ball.

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[3 marks]

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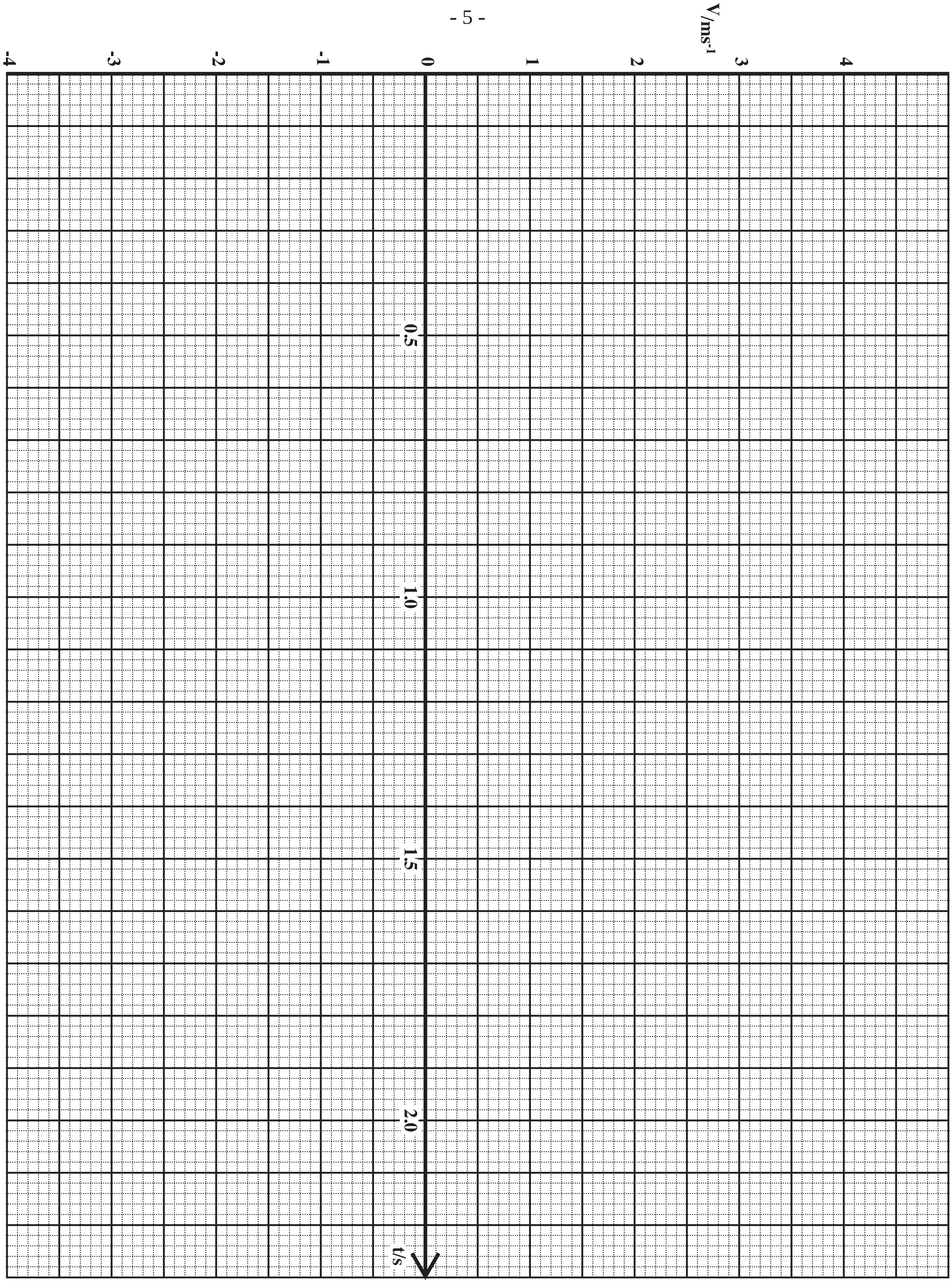

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(iii) Calculate

a) the acceleration of the ball down the inclined plane

[2 marks]

b) the length of the incline

[2 marks]

c) the MEAN force experienced by the ball during the impact with the block.

[2 marks]

(iv) State, with a reason, whether the collision between the block and the ball is elastic or not.

____

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____

____

[2 marks]

Total 15 marks

NOTHING HAS BEEN OMITTED

2. (a) Draw rays to show the passage of **white** light through

(i) Figure 2, a diffraction grating

(ii) Figure 3, a triangular glass prism

(iii) Figure 4, a rectangular glass block. **[4 marks]**

Figure 2: Diffraction grating

Figure 4: Glass block

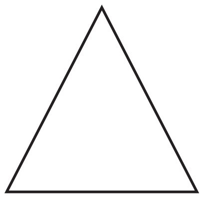

Figure 3: Prism

(b) The graph on page 9 shows the relationship between the sines of the angle of incidence, θ_1 and the angle of refraction, θ_2 for monochromatic yellow light travelling from glass to air.

(i) Use the graph to find the missing values of θ_1 and θ_2 and insert them in the table below.

θ_1	sin θ_1	θ_2	sin θ_2
31.0^o			
		75.2^o	
		90.0^o	

State the value of the critical angle of the glass. ____________________

[7 marks]

(ii) Describe what happens when the angle of incidence θ_1 is 55^o.

____

____

[1 mark]

(iii) Use the gradient of the graph to determine the refactive index of the glass for this colour light.

____

____

[3 marks]
Total 15 marks

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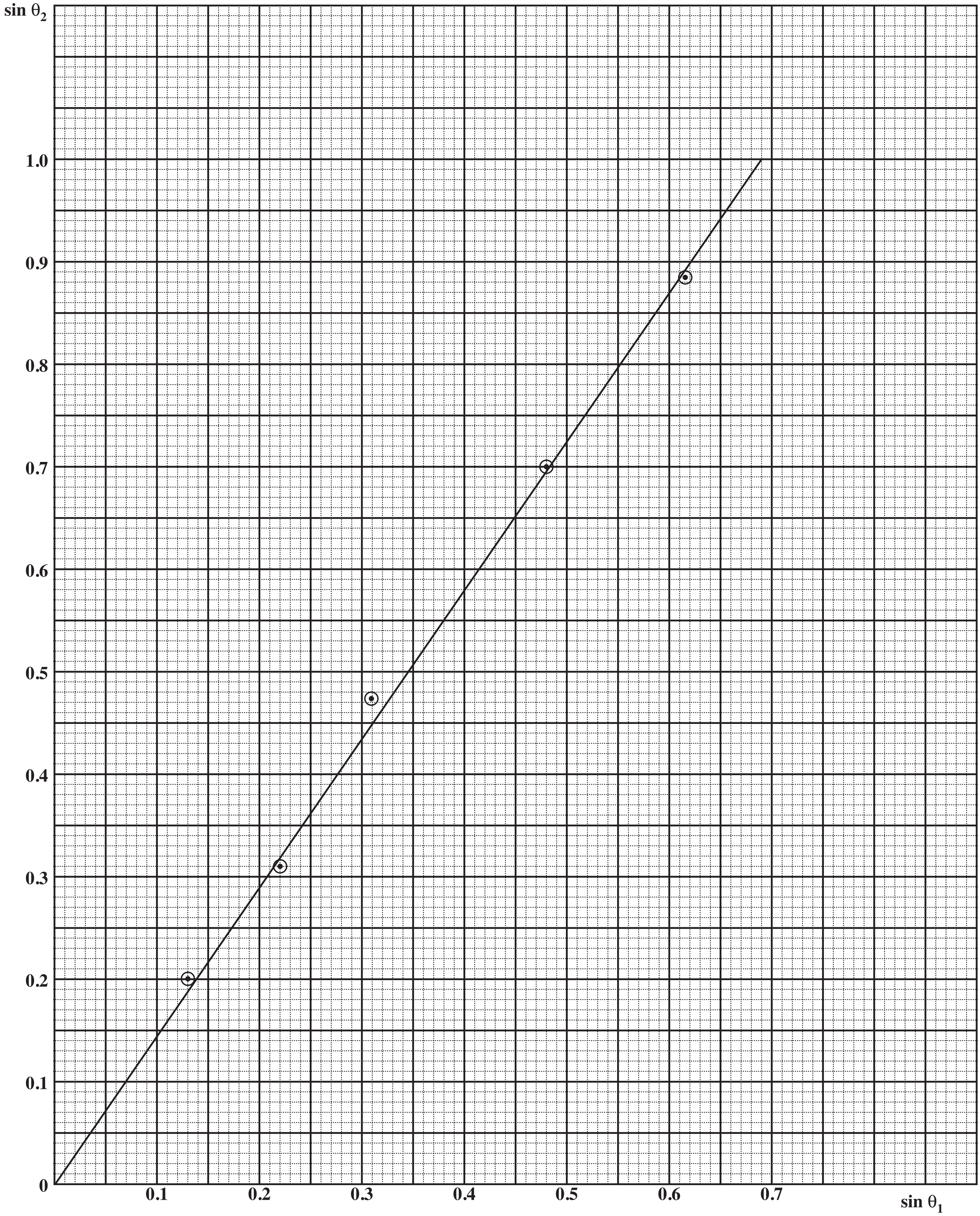

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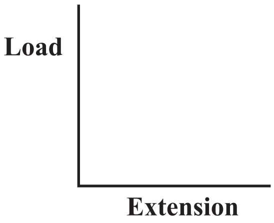
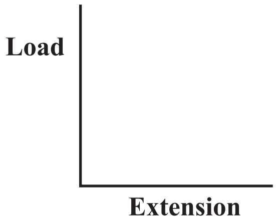
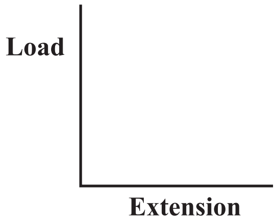
3. (a) (i) In the spaces provided, sketch graphs of load versus extension for a steel wire, glass and a polymeric material



Steel wire



Glass



Polymeric material

[3 marks]

(ii) Define the terms 'stress' and 'strain'.

Stress:

____

____

____

[1 mark]

Strain:

____

____

____

[1 mark]

(b) When a rubber strip with a cross-section of 3×10^{-3} m by 1.5×10^{-3} m is suspended vertically and various masses are attached to it, a student obtains the following data for length versus load.

Load, M/kg	0	0.1	0.2	0.3	0.4	0.5
Length, L/cm	5.0	5.6	6.2	6.9	7.8	10.0
Extension, ΔL / m	0					

(i) Fill in the missing values of extension, ΔL, in the table. **[1 mark]**

(ii) On the grid on page 11, draw a graph of load versus extension. **[4 marks]**

GO ON TO THE NEXT PAGE

(iii) Write an equation relating M and ΔL for small loads to Young's modulus E for the rubber.

Write an equation relating Young's modulus and the gradient of your graph for small loads.

[2 marks]

(iv) Use your graph to determine Young's modulus for the rubber for small loads.

[4 marks]

Total 15 marks

SECTION B

Answer ALL questions in this section.
Write your answers in the spaces provided at the end of each question.

4. (a) (i) State the conditions necessary for a body to be in equilibrium under the action of coplanar forces.

(ii) A block weighing 150 N hangs from a cord. It is pulled aside, as shown in Figure 5, by a horizontal force F. Find the tension in the cord and the magnitude of F.

[7 marks]

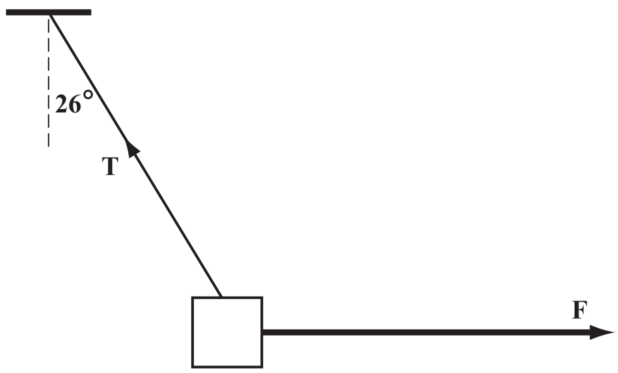


Figure 5

(b) A boy jumps off a flat-bed truck that is 2.2 m high. The initial velocity of the boy is 1.6 m s^{-1} at an angle 20° above the horizontal.

(i) State the horizontal and vertical components of the initial velocity.

(ii) Calculate the time taken for the boy to reach the ground.

(iii) How far horizontally from the truck does the boy land?

[8 marks]

Total 15 marks

Write your answer to Question 4 here.

Write your answer to Question 4 here.

5. Use the data presented in Figure 6 to answer this question.

(a) Figure 6 shows how the intensity and intensity level of the human ear vary with frequency.

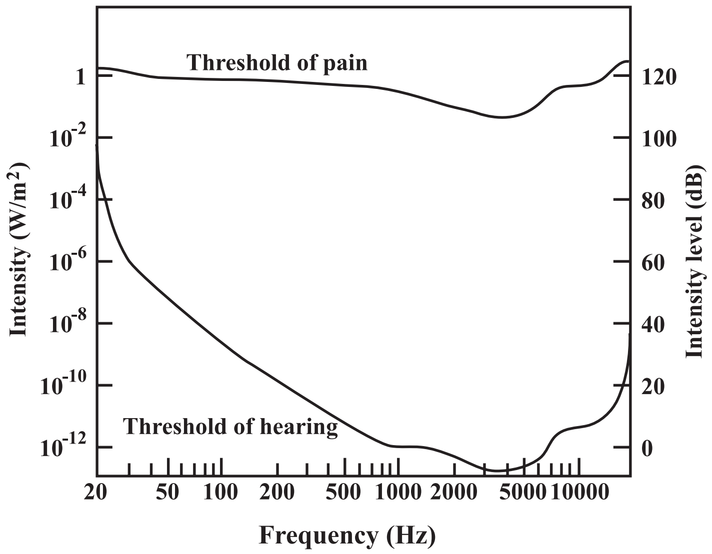


Figure 6

(i) Explain what is meant by 'threshold of hearing' and 'threshold of pain'.

(ii) What property of the human ear makes the decibel (dB) scale particularly useful?

(iii) Write down an expression that relates the sound intensity I, to the intensity level β, in dB.

(iv) What is the intensity level of a sound with intensity 3.82 mW m^{-2}?

(v) Figure 6 is drawn for a typical human ear. Suggest how the figure might change as a person ages.

[7 marks]

(b) Figure 7 shows a loudspeaker connected to an audio-frequency signal generator/amplifier that is set up in front of a large flat wall. A small microphone moved between the speaker and the wall detects regions of low and high intensity.

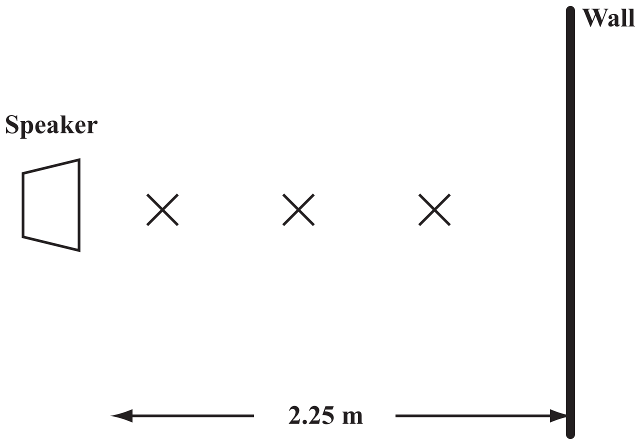


Figure 7

(i) Explain why there are positions between the speaker and the wall where intensity is a minimum and why these minima do NOT actually have zero intensity.

(ii) The points labelled X on Figure 7 are the only three points of minimum intensity detected at a certain frequency setting. What is the frequency?

(iii) When the signal generator is set at 165 Hz how far from the wall is the last **maximum** intensity position?

[Velocity of sound = 330 m s^{-1}]

[8 marks]

Total 15 marks

Write your answer to Question 5 here.

GO ON TO THE NEXT PAGE

Write your answer to Question 5 here.

6. (a) (i) A hot object emits electromagnetic waves. Explain in terms of the kinetic theory how this radiation is able to warm a distant cold body.

(ii) The Earth's surface is said to be warming up due to the accumulation of carbon dioxide and other gases in the atmosphere. Explain this 'greenhouse effect'.

[5 marks]

(b) A black woodstove with a total surface area 4.6 m^2 is made from cast iron 4.0×10^{-3} m thick. The interior wall of the stove is at 650 °C while the exterior wall is at 647 °C. The temperature of the surrounding air is 30 °C.

Calculate

(i) the rate of the heat conduction through the stove wall

(ii) the net rate of heat loss by radiation from the stove, assuming it acts as a black body

(iii) the heat the stove loses by a combination of conduction and convection in the surrounding air. Explain your answer.

(Thermal conductivity of cast iron, k = 80.4 $Wm^{-1}K^{-1}$)

[10 marks]

Total 15 marks

Write your answer to Question 6 here.

Write your answer to Question 6 here.

END OF TEST

TEST CODE **02138032**

FORM TP 2010234

MAY/JUNE 2010

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 01 – Paper 03/2

ALTERNATIVE TO SBA

2 hours

Candidates are advised to use the first 15 minutes for reading through this paper carefully.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **THREE** questions. Candidates must attempt **ALL** questions.

2. The use of non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

1. Design an experiment, using the principle of moments, to determine the upthrust on an object totally immersed in water.

List of apparatus:

[5 marks]

Diagram of setup:

[2 marks]

Procedure, including precautions taken:

[6 marks]

Manipulation of results:

[1 mark]

Calculation of upthrust:

[2 marks]

Total 16 marks

2. This experiment involves with the use of a diffraction grating.

(a) (i) Set up the apparatus as shown in Figure 1. Place the converging lens on top of the diffraction grating and adjust the height of the grating so that a sharp image of the filament of the lamp is focused on the paper on the bench.

[2 marks]

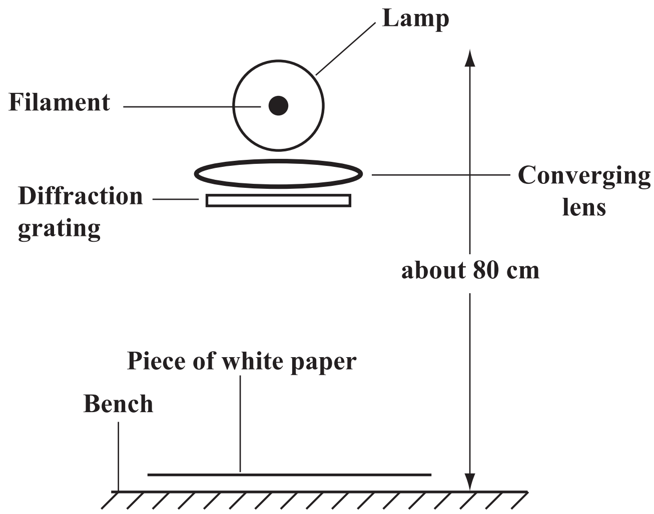


Figure 1

Measure the following distances:

(ii) The distance, u, from the centre of the lens to the filament.

____

[1 mark]

(iii) The distance, v, from the centre of the lens to the bench.

____

[1 mark]

(iv) The distance, D, from the diffraction grating to the bench.

____

[1 mark]

(b) Calculate the power, P, of the lens using the formula

$$P = \frac{1}{u} + \frac{1}{v}$$

where u and v are measured in metres.

[2 marks]

(c) (i) Mark on the piece of white paper the limits of the <u>first order</u> visible spectrum on either side of the image of the filament. **[1 mark]**

(ii) Sketch the first order spectra in the box below and record on the sketch the distances between the two red limits and the two violet limits.

[3 marks]

(iii) Use your readings, the information on the diffraction grating given on the card, and the diffraction grating formula,

$a \sin\theta = \lambda$

where $a = \frac{1}{N}$

N = number of lines per metre of the grating

λ = wavelength,

to establish the wavelength limits of the visible spectrum.

[5 marks]

Total 16 marks

GO ON TO THE NEXT PAGE

NOTHING HAS BEEN OMITTED

3. (a) The measuring instruments below were used to measure quantities in an experiment to determine the Young's modulus of steel in the form of a long straight wire.

(i) Read off the values indicated on the measuring instruments shown in Figure 2 and Figure 3 and state what quantity is measured by the instrument in the experiment.

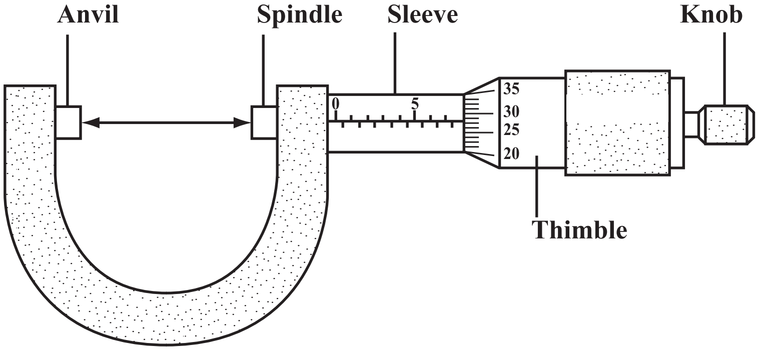


Figure 2

Reading = ______________________________

____

[2 marks]

(ii)

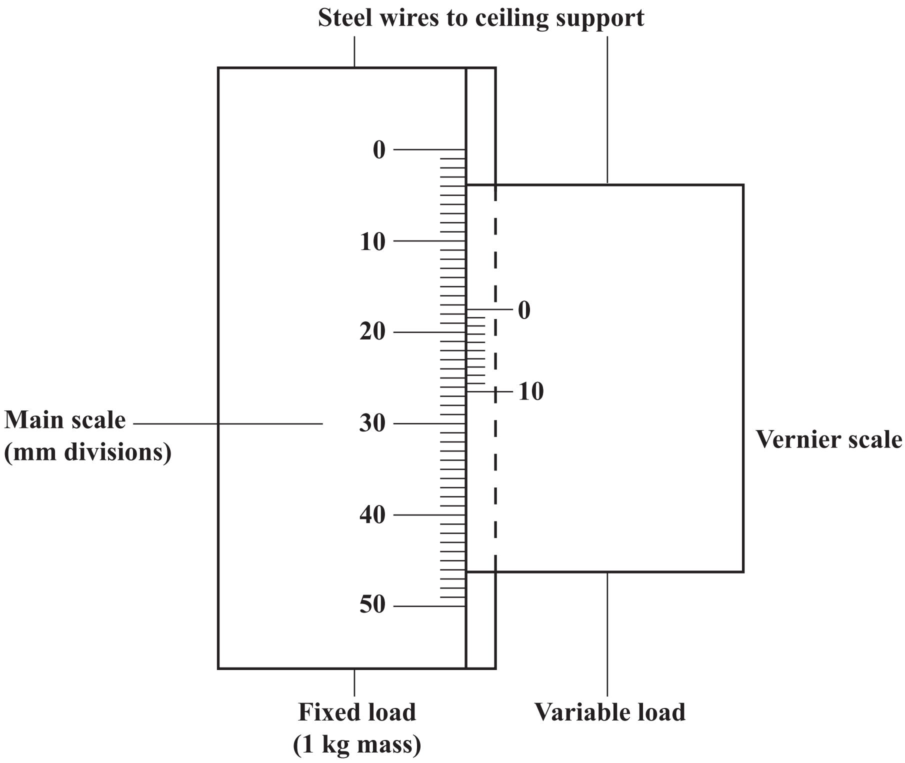


Figure 3

Reading = ______________________________

____

[2 marks]

(b) Explain why in the experiment

(i) a long wire was used

____

____

[1 mark]

(ii) a thin wire was used.

____

____

[1 mark]

(c) The following data were obtained in an experiment to determine the Young's modulus of steel in the form of a long wire. The unstretched length of the wire is 1.53 m. Values for the diameter, D, of the wire, which were taken along the length of the wire, are:

Diameter D = 0.46 mm; 0.46 mm; 0.47 mm; 0.46 mm; 0.47 mm; 0.47 mm.

(i) Calculate the cross-sectional area *A*, of the wire using the formula

$$A = \frac{\pi D^2}{4} \; .$$

[1 mark]

(ii) Complete the Table 1 by filling in the empty columns in the table.

Table 1

Load, kg	**Extension, x 10^{-4} m**	**Stress Nm^{-2}**	**Strain**
1.0	6		
2.0	11		
3.0	14		
4.0	19		
5.0	24		

[**2 marks]**

GO ON TO THE NEXT PAGE

(iii) Plot on page 11 a graph of stress vs strain for the wire. **[4 marks]**

(iv) Determine the Young's modulus for the wire.

[3 marks]

Total 16 marks

END OF TEST

TEST CODE **02238020**

FORM TP 2010236

MAY/JUNE 2010

C A R I B B E A N E X A M I N A T I O N S C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **SIX** questions.

2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.

3. Section B consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.

4. All working **MUST** be **CLEARLY** shown.

5. The use of non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_o	=	8.85×10^{-12} F m^{-1}
			$\frac{1}{4\pi\varepsilon_o} = 9.0 \times 10^{9}$ m f^{-1}
Elementary charge	e	=	1.60×10^{-19} C
Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant (Energy equivalence: 1u = 93 Mev)	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Answer ALL questions.

You MUST write your answers in the spaces provided in this answer booklet.

1. (a) (i) Define the term 'capacitance'.

[1 mark]

(ii) A capacitor with a capacitance of 2100 μF is charged until the potential difference between its plates is 6.0 V. Determine

a) the charge on one of the plates

[2 marks]

b) the energy stored by the capacitor.

[2 marks]

(b) A student set up the circuit shown in Figure 1 and after closing the switch, S, observed how the voltmeter reading varied with time. A graph of the data obtained is shown in Figure 2. Noting that the voltmeter reading decreased as time elapsed the student proposed the hypothesis that the voltmeter reading *V* is inversely proportional to the elapsed time *t*.

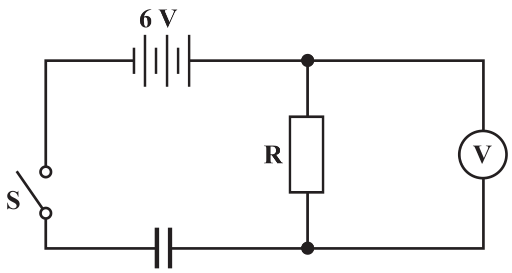


Figure 1

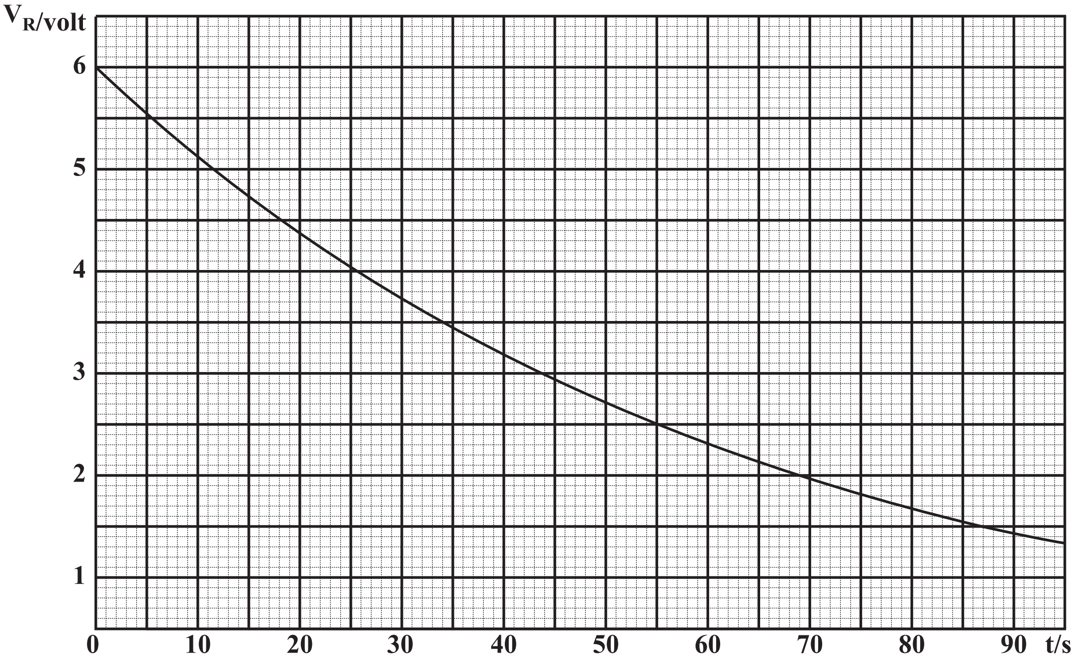


Figure 2. Graph of V_R vs Time

(i) Test his hypothesis by taking data from the graph in Figure 2 to complete Table 1 and then plotting $1/V$ against t on the grid provided on page 5.

TABLE 1

t/s	*V*/V	1/*V*
15		
30		
45		
60		
75		
90		

[8 marks]

(ii) State, with reasons, the conclusion which may be drawn from the data.

____

____

____

[2 marks]

Total 15 marks

NOTHING HAS BEEN OMITTED

2. (a) In relation to a semi-conductor

(i) explain what is meant by

a) P-type material

[1 mark]

b) N-type material

[1 mark]

c) the depletion region.

[1 mark]

(ii) Draw a diagram of a junction transistor and draw the transistor symbol.

[2 marks]

GO ON TO THE NEXT PAGE

(b) The current, I, through the p-n junction of a diode is related to the voltage across the junction, *V*, by the expression

$$I = I_O \exp\left[\frac{e\,V}{nkT}\right]$$

where I_O is the saturation current; *n* is the junction ideality factor; *k* is the Boltzman's constant and T is the temperature in kelvin. Some d.c. measurements made on a silicon diode at 300 K, yielded the following results:

TABLE 2

V/Volt	I/µA	ℓn (I/µA)
0.490	1	
0.568	10	
0.647	100	
0.732	1000	
0.818	5000	

(i) Complete Table 2 by filling in the missing values. **[1 mark]**

(ii) Plot a graph of *ℓn I* versus *V* on the grid opposite . Draw your best straight line through the points. **[4 marks]**

(iii) Write the equation relating *ℓn I* and *V*.

[1 mark]

(iv) Determine the ideality factor *n*.

[4 marks]

[Data: k = 1.38 x 10^{-23} J K^{-1}]

Total 15 marks

3. (a) The radioactive gas Radon-220, an α–emitter, is easily separated from its powdered solid parent and is known to have a short half-life. Describe how you would accurately measure the half-life of Radon. In your account give details of the apparatus required, the procedure to be followed and the way the collected data will be processed.

[7 marks]

(b) The half-life of Radon-220 is actually 54 seconds: it decays by the emission of α-particles, one particle being emitted for each atom decaying.

(i) How many α-particles would be emitted by a 4 mg sample of $^{220}_{86}Rn$ in 108 seconds?

[5 marks]

(ii) A laboratory is deemed safe after a Radon-220 leak when the activity has decreased to less than 0.1% of its original value. What is the MINIMUM number of minutes for which the laboratory must remain closed?

[3 marks]

Total 15 marks

SECTION B

Answer ALL questions in this section.
Write your answers in the spaces provided in this answer booklet.

4. (a) State Kirchhoff's two laws for electrical circuits and give the physical principle that each law is based on. **[4 marks]**

(b) Distinguish between the 'e.m.f.' and the 'terminal p.d.' of a cell. **[2 marks]**

(c) Figure 3 shows a network of resistors and batteries. The internal resistance of each battery is 1Ω as shown.

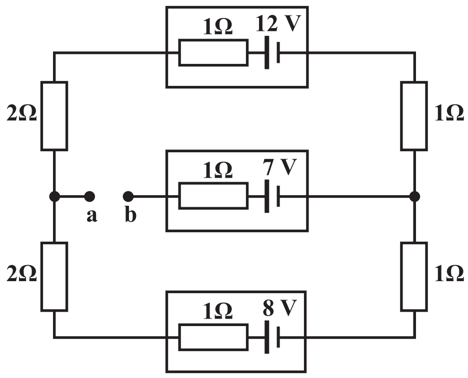


Figure 3

(i) Calculate the current flowing through the 12 V battery.

(ii) Points *a* and *b* are connected by a wire of negligible resistance. Calculate the new value for the current that will flow through the 12 V battery. **[9 marks]**

Total 15 marks

Write your answer to Question 4 here.

Write your answer to Question 4 here.

5. Figure 4 shows an ideal non-inverting operational amplifier (op-amp) circuit.

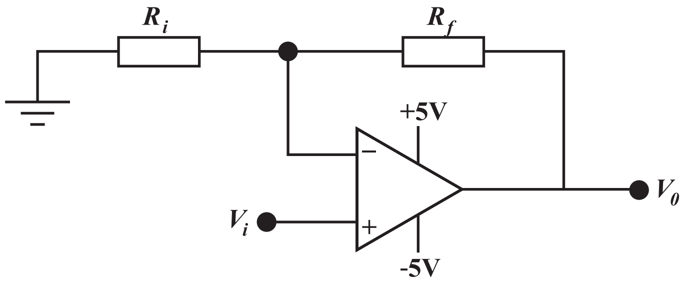


Figure 4

(a) Show that the closed loop gain, A, of the circuit is given by $A = \dfrac{R_i + R_f}{R_i}$. Clearly state any assumptions made about the properties of the op-amp. **[5 marks]**

(b) A circuit like the one in Figure 4 is set up with $R_f = 440$ kΩ and $R_i = 40$ kΩ. The op-amp is operated from a ± 5.0 V supply.

(i) What is the value of the output voltage when is $V_i = +250$ mV?

(ii) If the op-amp is NOT to be saturated, what is the MAXIMUM voltage amplitude for the input signal?

(iii) Sketch a graph to show the expected output when a sinusoidal signal with an amplitude of 0.75 V is applied to the input of this amplifier.

[6 marks]

(c) In a certain application, it is desired to combine two signals, v_1 and v_2, to form a signal v_0 according to the relation $v_0 = -2\,v_1 - 5\,v_2$ The minimum input resistance for both signal inputs should be NO less than 10.0 kΩ. Design a circuit to meet this requirement.

[4 marks]

Total 15 marks

Write your answer to Question 5 here.

Write your answer to Question 5 here.

6. (a) With the aid of a sketch graph, clearly explain the following terms and how they originate.

(i) Continuous X-ray spectrum

(ii) Characteristic X-ray spectrum

(iii) Cut-off wavelength **[7 marks]**

(b) The x-ray tube in Figure 5 operates at 50 kV and the current through it is 1.2 mA.

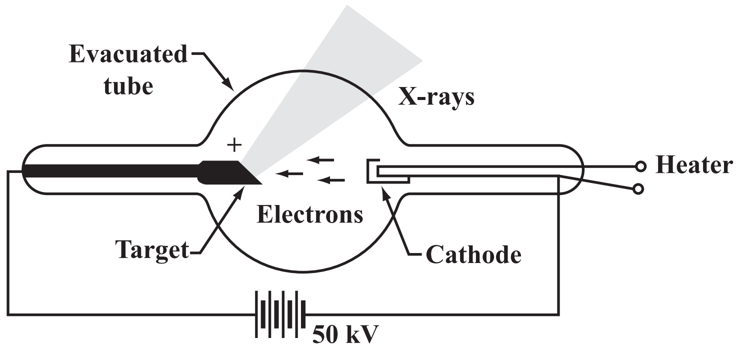


Figure 5

Calculate

(i) the electrical power input

(ii) the speed of the electrons when they hit the target

(iii) the cut-off wavelength of the X-rays emitted.

[8 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

Write your answer to Question 6 here.

END OF TEST

FORM TP 2010237

TEST CODE **02238032**

MAY/JUNE 2010

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 02 – Paper 03/2

ALTERNATIVE TO SBA

2 hours

Candidates are advised to use the first 15 minutes for reading through this paper carefully.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **THREE** questions. Candidates must attempt **ALL** questions.

2. The use of non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

1. The current I, flowing through a filament bulb is related to the voltage V, across the bulb by the equation $I = kV^n$ where k and n are constants.

Design an experiment to determine the constants k and n.

List of apparatus:

____

____

____

____

____

____

[5 marks]

Circuit diagram:

[2 marks]

GO ON TO THE NEXT PAGE

Procedure, including precautions taken:

[5 marks]

Manipulation of results:

[1 mark]

Calculations of k and n.

[3 marks]

Total 16 marks

2. (a) Assemble the circuit of the non-inverting amplifier as shown in Figure 1. (A data sheet with the pin-out of the 741 OP-AMP will be provided if necessary.)

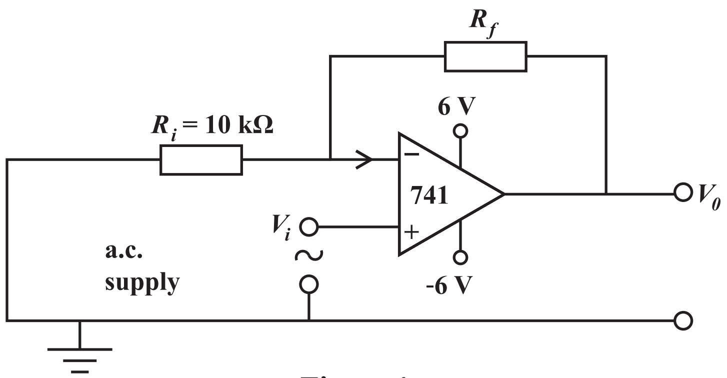


Figure 1

[2 marks]

(b) The feedback resistor, R_f, is an unknown resistance whose value has to be determined. The input resistance, R_i, is to be set at 10 kΩ.

(i) Using the multimeter, take at LEAST six different measurements of the input voltage V_i and the corresponding output voltage V_o. Make sure to keep the output voltage, V_o, below saturation level.

Input voltage, V_i/Volts	**Output voltage V_o/Volts**

[3 marks]

(ii) Now, measure and record the output voltage at which saturation of the circuit occurs.

____

[1 mark]

(c) (i) Plot a graph of V_o vs V_i on the grid on page 5. **[5 marks]**

GO ON TO THE NEXT PAGE

(ii) Use your graph to determine the closed loop gain, A_{cl}, of the non-inverting amplifier circuit.

[2 marks]

(iii) Determine the value of the unknown resistor R_f in the circuit.

[3 marks]

Total 16 marks

NOTHING HAS BEEN OMITTED

3. (a) The activity of a sample of radioactive material was monitored over 12 hours, and the following net count rates, after the background count rates were subtracted, were obtained. The results were recorded in Table 1.

TABLE 1

Time/(hours)	**Corrected count rate, C, /(counts per minute)**
1	3100
2	2450
4	1480
6	910
8	545
10	330
12	200

(i) Plot a graph of corrected count rate, C vs time/hours on the grid on page 9.

[6 marks]

(ii) Explain how you would determine the background count rate.

____

____

____

____

____

____

____

____

[1 mark]

(b) (i) Determine the half-life of the radioactive nuclei in the sample.

[3 marks]

(ii) Determine the decay constant of the radioactive nuclei in the sample.

[2 marks]

(iii) Read off from your graph the count rate for the sample at t = 0.

[1 mark]

(iv) Assuming the efficiency of the counting instrument to be 10%, calculate the number of radioactive atoms in the sample at t = 0.

[3 marks]

Total 16 marks

END OF TEST

TEST CODE **02138032 – IS**

FORM TP 2010234 – IS

MAY/JUNE 2010

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 01 – Paper 03/2

ALTERNATIVE TO INTERNAL ASSESSMENT

24 MAY 2010 (a.m.)

INSTRUCTIONS FOR SETTING UP THE ALTERNATIVE TO INTERNAL ASSESSMENT EXAMINATION

Question 1

None

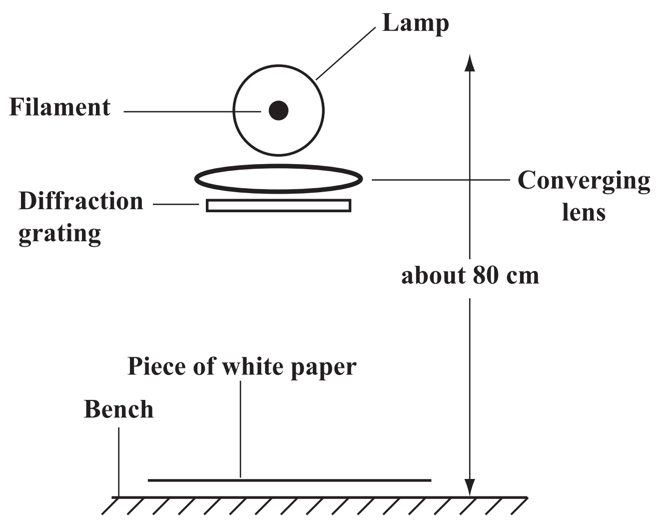
Question 2

Apparatus required for EACH candidate:

1. 12 V, 24 W lamp, with a suitable power supply. The coiled lamp filament should be straight.
2. Diffraction grating having 300 line mm^{-1}.
3. Stand, at least 80 cm high, with two bosses and clamps.
4. Piece of white paper, about legal size (8.5 in x 14 in).
5. Converging lens, focal length 10 cm.
6. Metre rule.
7. Card stating: "Diffraction grating has 300 lines per millimetre".

The experiment should be performed in a part of the laboratory where there is dim light.

Item 1 – 4 should be assembled above the bench as shown in Figure 1, with the lamp filament horizontal. The grating should be clamped a few centimetres below the lamp with its rulings parallel to the filament. The paper should be placed on the bench with its shorter sides parallel to the filament.



In the experiment the candidate is required to place the lens (item 5) on top of the grating and then move the grating so that a sharp image of the filament is formed on the paper.

The Supervisor checks that this will be possible but removes the lens and changes the position of the grating after doing so.

Question 3

None

END OF INSTRUCTIONS

TEST CODE **02138032 – SR**

FORM TP 2010234 – SR

MAY/JUNE 2010

SCHOOL/CENTRE NUMBER					

NAME OF SCHOOL/CENTRE

C A R I B B E A N E X A M I N A T I O N S C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 01 – Paper 03/2

ALTERNATIVE TO INTERNAL ASSESSMENT

24 MAY 2010 (a.m.)

SUPERVISOR'S REPORT ON THE ALTERNATIVE TO INTERNAL ASSESSMENT EXAMINATION

When completed, this report MUST accompany candidates' answer booklets for the Practical Examination.

SUPERVISOR'S NAME
(Please print)

SUPERVISOR'S SIGNATURE

The attention of supervisors is drawn to the following:

(a) ASSISTANCE TO CANDIDATES

Candidates MUST be told before the test begins that:

(i) Help will be available to those candidates who need it in order to proceed with the experiment, but that such help will be given to a candidate only if he/she requests it. Assistance should be confined to guidance in setting up apparatus or describing procedure to enable candidates to obtain readings. Help with the interpretation of graphs, the determination of gradients or calculations and formulae is NOT to be given.

(ii) Wherever such assistance is given, a full report must be submitted to the examiners of the nature and extent of it.

(iii) Candidates who receive help are liable to suffer a loss of marks.

Supervisors will appreciate the need for such reports to be accurate if candidates who receive help are to be fairly assessed. They are therefore requested in submitting their reports to state the nature and extent of the assistance given in the space allotted in the candidate's answer booklet (see diagram in (b) below), and also in the space provided on page 5 in this report form. In any report it is important to include the candidate's number as well as name.

N.B. Help is not to be offered to any candidate.

(b) DATA TO BE SUPPLIED TO CXC

Data are to be supplied on this report form in the space provided. In addition, they should be given on the right-hand half of the inside of the front cover of each candidate's answer booklet. (See diagram below.) This should be done only AFTER THE COMPLETION OF THE EXAMINATION.

DO NOT	[DATA: ←]	Data, if any, on this side of this page
WRITE	ASSISTANCE	
IN THIS	TO	
SPACE	CANDIDATE ←	Assistance given

FRONT INSIDE COVER OF ANSWER BOOKLET

(c) Only apparatus stipulated in the "Instructions to Supervisors" booklet is to be supplied to the candidate. The issue of additional equipment or apparatus is NOT allowed.

(d) The declaration form on page 6 is to be signed as indicated before this report is submitted.

GO ON TO THE NEXT PAGE

Information required from Supervisor:

Question 1

Specification for the thermistor

Question 2

Specimen set of results in the same format as that presented by the candidates.

Question 3

None

General Remarks. Here the Supervisor may give an account of any incident(s) which he/she thinks should be communicated to the examiners, in order that they may fairly assess the performance of the candidate and the quality of his/her work.

Report on Assistance Given. (If necessary, continue on page 6.)

GO ON TO THE NEXT PAGE

Declaration: (Delete as appropriate).

I/We declare that NO assistance was given to any candidate during the examination.

I/We declare that ALL assistance given during the examination has been reported above.

Teacher's Signature Supervisor's Signature

. . . .

Date: . . . .

TEST CODE **02238032 – IS**

FORM TP 2010237 – IS

MAY/JUNE 2010

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 02 – Paper 03/2

ALTERNATIVE TO INTERNAL ASSESSMENT

13 MAY 2010 (a.m.)

INSTRUCTIONS FOR SETTING UP THE ALTERNATIVE TO INTERNAL ASSESSMENT EXAMINATION

Question 1

None

Question 2

Apparatus required for EACH candidate:

Op. Amp circuit board to make a non-inverting amplifier

or

741 Operational Amplifier

741 OP-AMP data sheet showing pinouts and wiring configurations

electronic breadboard/project board with DC + 6 V and – 6 V connections

1 power supply ± 6 V d.c. for Op. Amp.

2 digital multimeters to measure a.c. volts *

1 variable a.c. supply (low voltage e.g. 0 – 12 V)**

1 10 kΩ standard resistor

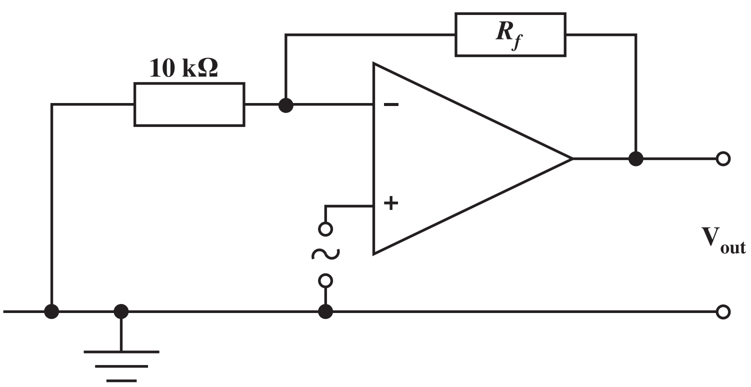
1 220 kΩ standard resistor (or nearest available value) and wires to connect this as the feedback resistor

The 220 kΩ standard resistor should be covered with a sheath, or painted with "ink-out" so that the candidate cannot read the resistor code, and labelled R_F.

***** If necessary one meter could work: candidates should be informed that they must connect across in the input, then move the connection to the output.

** Candidates will be advised to keep the voltage below saturation level.

<u>Circuit</u> to be connected by candidates



Question 3

None

END OF INSTRUCTIONS

FORM TP 2010237 – SR

MAY/JUNE 2010

SCHOOL/CENTRE NUMBER					

NAME OF SCHOOL/CENTRE

C A R I B B E A N E X A M I N A T I O N S C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 02 – Paper 03/2

ALTERNATIVE TO INTERNAL ASSESSMENT

13 MAY 2010 (a.m.)

SUPERVISOR'S REPORT ON THE ALTERNATIVE TO INTERNAL ASSESSMENT EXAMINATION

When completed, this report MUST accompany candidates' answer booklets for the Practical Examination.

SUPERVISOR'S NAME
(Please print)

SUPERVISOR'S SIGNATURE

The attention of supervisors is drawn to the following:

(a) ASSISTANCE TO CANDIDATES

Candidates MUST be told before the test begins that:

(i) Help will be available to those candidates who need it in order to proceed with the experiment, but that such help will be given to a candidate only if he/she requests it. Assistance should be confined to guidance in setting up apparatus or describing procedure to enable candidates to obtain readings. Help with the interpretation of graphs, the determination of gradients or calculations and formulae is NOT to be given.

(ii) Wherever such assistance is given, a full report must be submitted to the examiners of the nature and extent of it.

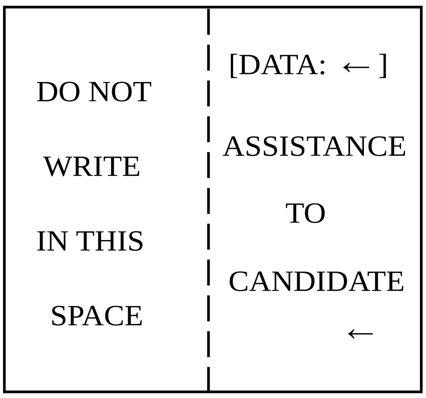
(iii) Candidates who receive help are liable to suffer a loss of marks.

Supervisors will appreciate the need for such reports to be accurate if candidates who receive help are to be fairly assessed. They are therefore requested in submitting their reports to state the nature and extent of the assistance given in the space allotted in the candidate's answer booklet (see diagram in (b) below), and also in the space provided on page 5 in this report form. In any report it is important to include the candidate's number as well as name.

N.B. Help is not to be offered to any candidate.

(b) DATA TO BE SUPPLIED TO CXC

Data are to be supplied on this report form in the space provided. In addition, they should be given on the right-hand half of the inside of the front cover of each candidate's answer booklet. (See diagram below.) This should be done only AFTER THE COMPLETION OF THE EXAMINATION.



Data, if any, on this side of this page

Assistance given

FRONT INSIDE COVER OF ANSWER BOOKLET

(c) Only apparatus stipulated in the "Instructions to Supervisors" booklet is to be supplied to the candidate. The issue of additional equipment or apparatus is NOT allowed.

(d) The declaration form on page 6 is to be signed as indicated before this report is submitted.

GO ON TO THE NEXT PAGE

Information required from Supervisor:

Question 1

None

Question 2

- Details of circuit supplied.
- Sample results in same format as that required for candidates.
- Value of feedback resistance

Question 3

None

General Remarks. Here the Supervisor may give an account of any incident(s) which he/she thinks should be communicated to the examiners, in order that they may fairly assess the performance of the candidate and the quality of his/her work.

Report on Assistance Given. (If necessary, continue on page 6.)

GO ON TO THE NEXT PAGE

Declaration: (Delete as appropriate).

I/We declare that NO assistance was given to any candidate during the examination.

I/We declare that ALL assistance given during the examination has been reported above.

Teacher's Signature　　　　　　　　　　Supervisor's Signature

. . . .　　　　　　. . . . .

Date: . . . .

TEST CODE **02138020**

FORM TP 2011237

MAY/JUNE 2011

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 1 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of **SIX** questions, divided into Sections A and B.

2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.

3. Section B consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.

4. Diagrams may be drawn in pencil but **all writing** must be in **ink**.

5. All working **MUST** be **CLEARLY** shown.

6. The use of silent non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
Acceleration due to gravity	g	=	9.80 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^5 N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water		=	1.00×10^3 kg m^{-3}
Specific heat capacity of water		=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice		=	3.34×10^5 J kg^{-1}
Specific latent heat of vaporization of water		=	2.26×10^6 J kg^{-1}
Avogadro's constant	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan-Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in free space	c	=	3.00×10^8 m s^{-1}

SECTION A

Answer ALL questions.

You MUST write your answers in the spaces provided in this answer booklet.

1. (a) Figure 1 shows a skydiver of mass m falling under the influence of gravity and a drag force F_d that is proportional to v^n ($F_d = bv^n$), where v is the velocity of the skydiver as she falls, b is a constant and n is an integer.

Figure 1

(i) Next to Figure 1 draw a free body diagram to show the forces acting on the sky-diver. **[1 mark]**

(ii) Hence show that when her downward acceleration is a, the equation of motion for the skydiver can be written as

$$g - a = \frac{b}{m} \quad v^n .$$

[2 marks]

(b) Table 1 shows data recorded for the acceleration and velocity of the skydiver as she underwent free fall.

TABLE 1

Acceleration **a/m s^{-2}**	**Velocity** ***v*/ms^{-1}**	***g – a*/m s^{-2}**	**lg (*g – a*)**	**lg *v***
9.41	10			
8.91	15			
8.24	20			
7.36	25			
6.28	30			
5.00	35			

(i) Complete Table 1 by filling in the blank columns. **[3 marks]**

(ii) On page 4, plot a graph of lg (g – a) vs lg v. **[3 marks]**

(iii) Calculate the gradient of the graph and hence determine a value for n (to the nearest integer).

[3 marks]

(iv) Calculate the terminal velocity of a skydiver with a mass of 78.5 kg, given that b = 0.251 kg m^{-1}.

[3 marks]
Total 15 marks

GO ON TO THE NEXT PAGE

NOTHING HAS BEEN OMITTED.

2. (a) Figure 2 shows a loudspeaker sounding a constant note placed above a long vertical tube containing water which slowly runs out at the lower end.

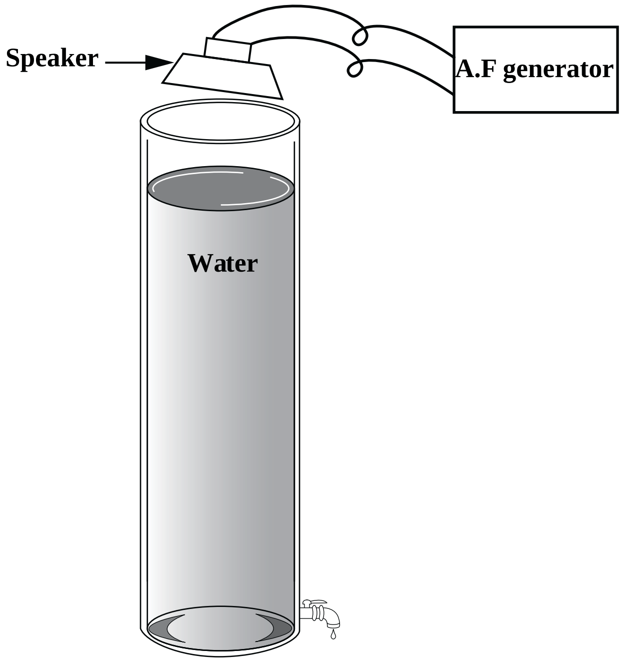


Figure 2

(i) Describe and explain what is heard at a certain level as the water runs out at the lower end.

____

____

____

____

____

____

[2 marks]

(ii) What name is given to this phenomenon?

____

[1 mark]

(b) The frequency of a vibrating string is given by $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$, where T is the tension in the string, μ is the mass per unit length of the string and l is the length of the string.

While the tension of a vibrating string was kept constant at 100 N, its length was varied in order to tune the string to a series of tuning forks. The results obtained are shown in Table 2.

TABLE 2

Frequency of Fork, *f* (Hz)	256	288	320	384	450	512
Length of String, *l* (*m*)	0.781	0.695	0.625	0.521	0.444	0.391
$1/l$ (m^{-1})						

(i) Complete the table by filling in the values for $1/l$. **[1 mark]**

(ii) On page 9, plot a graph of frequency f vs $1/l$. **[3 marks]**

(iii) Use the graph to determine the frequency of an unmarked fork which was in tune with 41.7 cm of the string.

[2 marks]

(iv) Calculate the gradient of the graph.

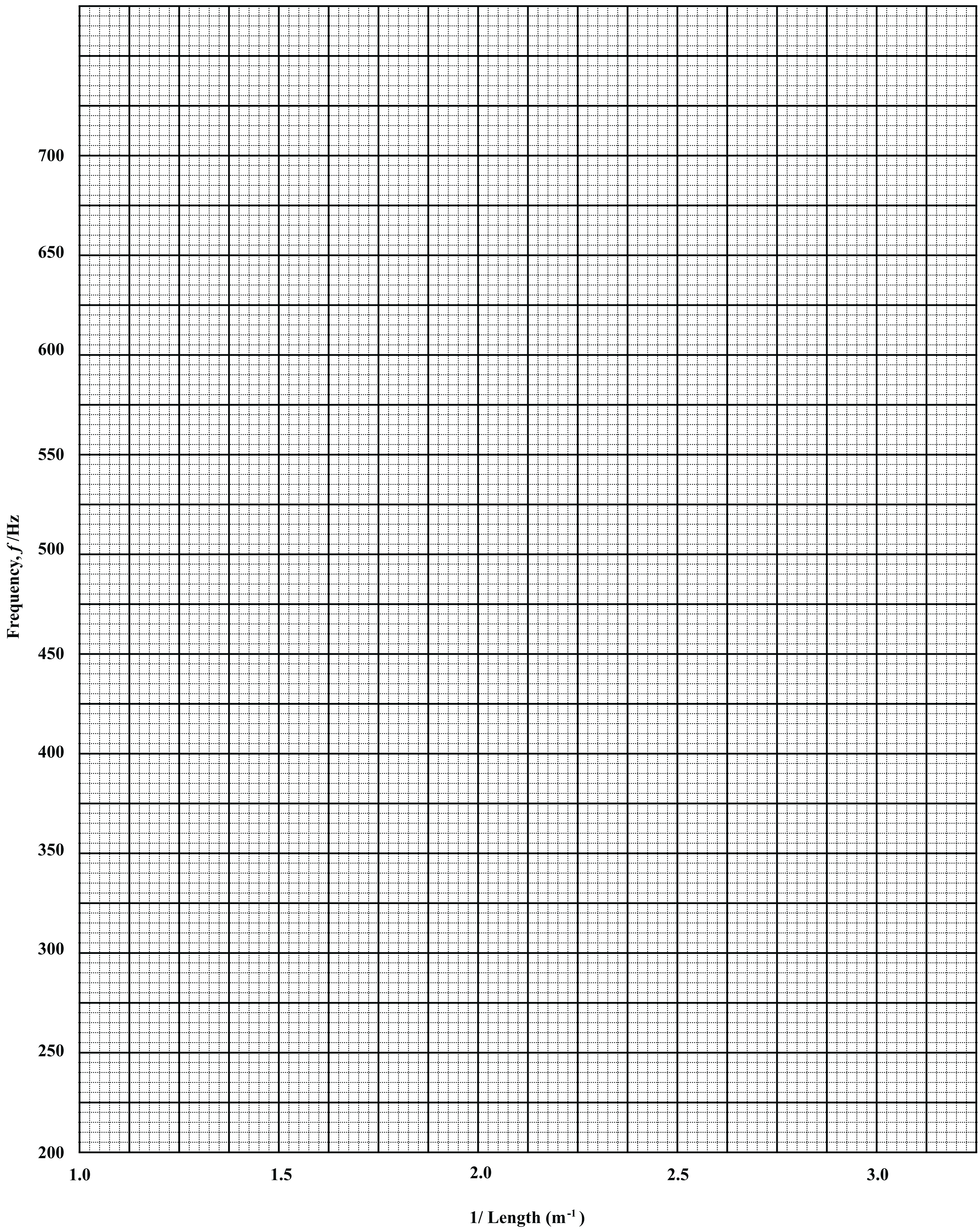
[3 marks]

(v) Determine the value of the mass per unit length, μ, of the wire.

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE



GO ON TO THE NEXT PAGE

3. (a) Define the term ‘specific latent heat of fusion’ of a substance.

____

____

[1 mark]

(b) A solid of mass 2.0 kg receives heat at the rate of 1.0×10^5 J per minute. Its temperature, T, (in K) during the first 45 minutes of the experiment is shown in the graph on the opposite page.

(i) What are the values of the melting point and boiling point of the substance?

Melting point __________________ Boiling point ________________________

[2 marks]

(ii) Calculate the gradient of the two linear regions of the graph labelled P and Q.

Gradient P

Gradient Q

[4 marks]

(iii) State, giving your reasoning, whether the specific heat capacity of the liquid is greater or smaller than that for the solid state.

____

____

[2 marks]

(iv) Calculate the specific heat capacity of the substance in the liquid state.

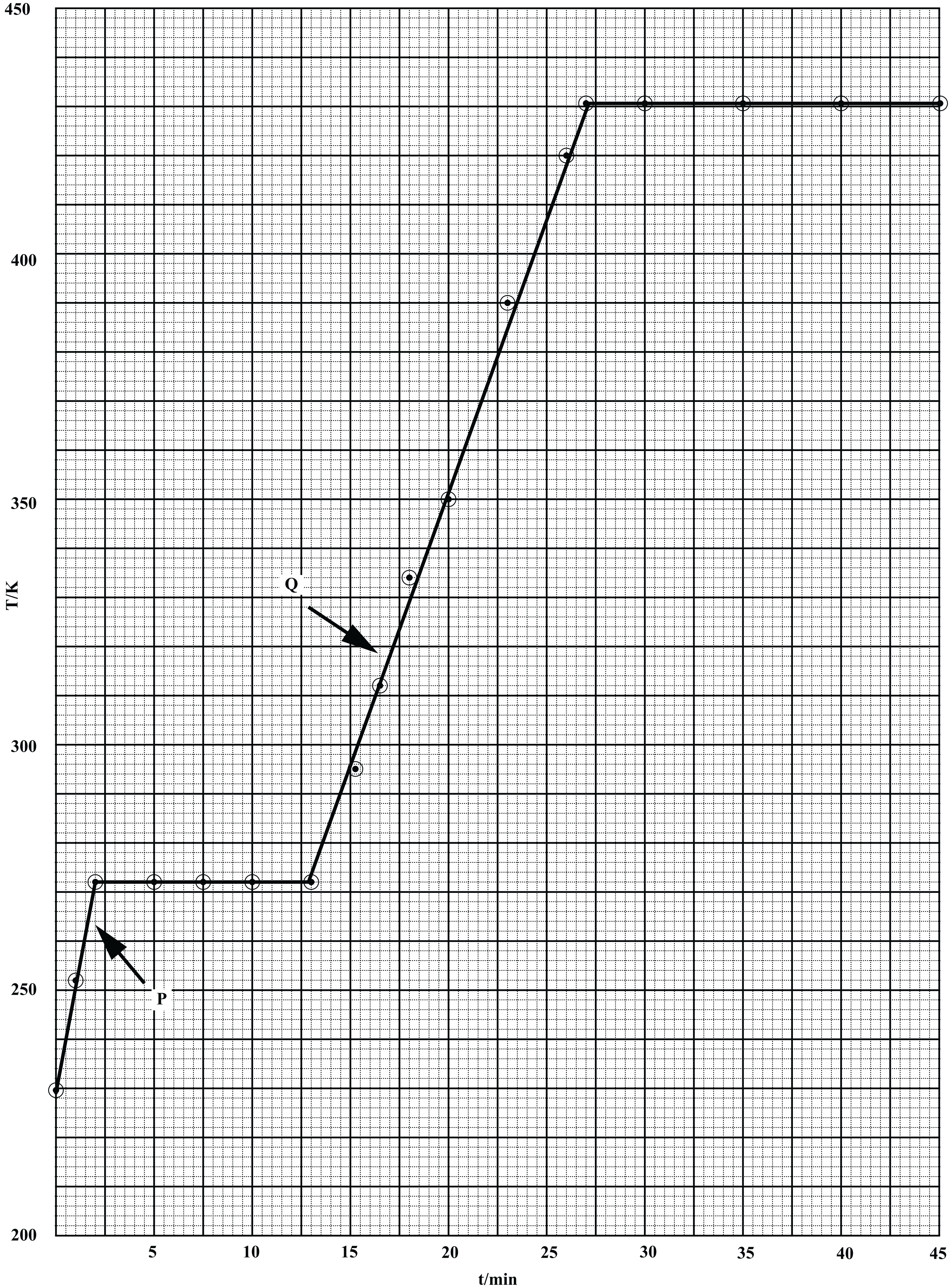
[3 marks]

(v) Calculate the specific latent heat of fusion of the substance.

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE


450
400
350
300
250
200
T/K
Q
P
5
10
15
20
25
30
35
40
45
t/min

SECTION B

Answer ALL questions.

Write your answers in the spaces provided at the end of the questions.

4. (a) (i) Distinguish between the 'kinetic energy' and the 'gravitational potential energy' of a body near the Earth's surface and write an expression for EACH.

(ii) Explain why it is possible for the TOTAL mechanical energy of a system to be negative, but NOT its kinetic energy.

[6 marks]

(b) Figure 3 shows a ski jump.

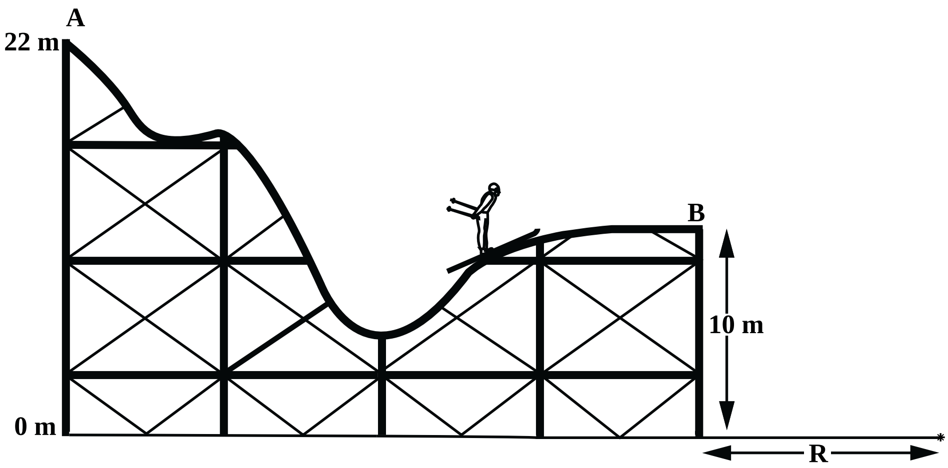


Figure 3

A ski jumper, of mass 60 kg, starts from rest at the top, A, of the jump track and follows, with its several ups and downs, the path of the track. The jump track starts at a height of 22 m above the eventual landing point. The jumper leaves the track while he moves horizontally at Point B which is exactly 12 m below the starting point.

Calculate the

(i) velocity of the skier at Point B, the end of the track

(ii) time the skier takes to hit the ground after he has left Point B

(iii) horizontal distance, R, of the end of the track, (Point B) from the landing point.

[7 marks]

(c) What TWO assumptions did you make in calculating the answers to (b) above?

[2 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

You MUST write the answer to Question 4 here.

4. (a)

(b)

(c) ____

____

____

____

____

5. (a) (i) Distinguish **clearly** between 'refraction' and 'diffraction' of light. Draw ray diagrams, ONE in EACH case, to illustrate EACH phenomenon. **[4 marks]**

(ii) Discuss how interference and diffraction contribute to the action of a diffraction grating. **[3 marks]**

(b) Light from glowing hydrogen contains two discrete spectral lines at 656.3 nm and 486.1nm. These two lines are viewed through a spectrometer using a diffraction grating with 6000 slits per cm. The spectra is viewed in the second order ($n = 2$).

Calculate the

(i) slit spacing of the diffraction grating, expressed in metres **[2 marks]**

(ii) angular positions of the two spectral lines **[5 marks]**

(iii) angular separation between the two spectral lines. **[1 mark]**

Total 15 marks

You MUST write the answer to Question 5 here.

5. (a)

(b)

6. Figure 4 shows some gas contained in a cylinder with a piston in thermal equilibrium at a temperature of 315 K. The cylinder is **thermally isolated from its surroundings**. Initially the volume of gas is 2.90×10^{-4} m^3 and its pressure is 1.03×10^5 Pa.

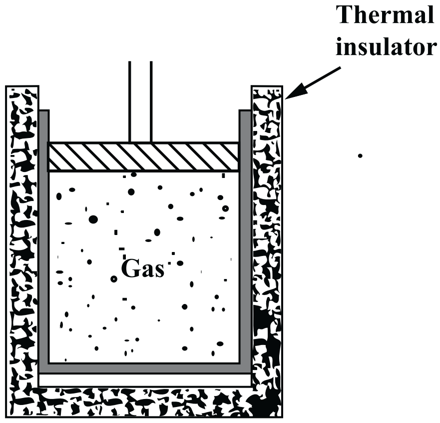


Figure 4

(a) Use the equation of state for an ideal gas to find the amount, in moles, of gas in the cylinder. **[3 marks]**

(b) The gas is then compressed to 3.5×10^{-5} m^3 and its temperature rises to 790 K. Explain this rise in temperature

(i) on a macroscopic scale, using the first law of thermodynamics **[3 marks]**

(ii) on a microscopic scale, using the kinetic theory of gases. **[3 marks]**

(c) Calculate the pressure of the gas after this compression. **[2 marks]**

(d) The work done on the gas during the compression is 90 J. Use the first law of thermodynamics to find the **increase** in the internal energy of the gas during the compression. **[1 mark]**

(e) Calculate the molar heat capacity of the gas in the container. **[3 marks]**

Total 15 marks

You MUST write the answer to Question 6 here.

6. (a)

(b)

GO ON TO THE NEXT PAGE

(c)

(d)

(e)

END OF TEST

FORM TP 2011238

TEST CODE **02138032**

MAY/JUNE 2011

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 1 – Paper 03/2

ALTERNATIVE TO SBA

2 hours

Candidates are advised to use the first 15 minutes for reading through this paper carefully.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of **THREE** questions. Candidates must attempt **ALL** questions.

2. The use of silent non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

1. Figure 1 (a) shows a ballistic balance used to compare two masses. Two unequal spheres are suspended by diverging threads from horizontal cross-pieces which are adjustable in position. A horizontal metre rule passes between the threads, and an electromagnet connected in circuit is fitted to the main stand. This experiment uses the principles of conservation of mechanical energy and conservation of momentum.

Figure 1 (a)

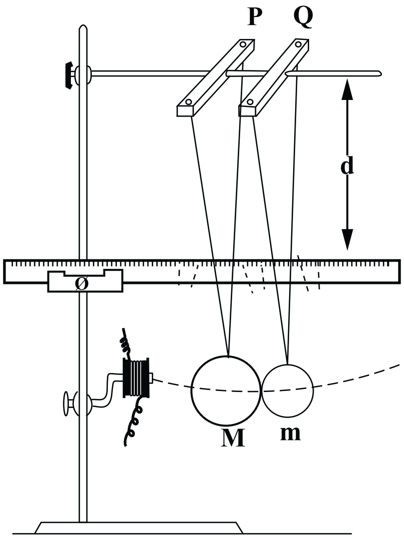
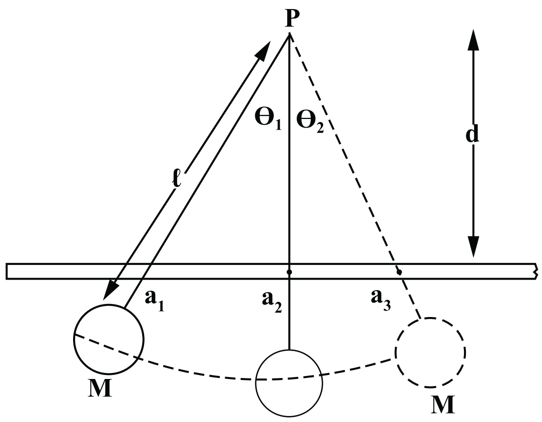
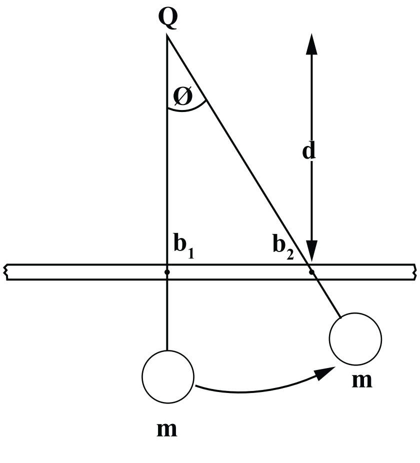


Figure 1 (b)



Motion of large sphere

Figure 1 (c)



Motion of small sphere

(a) Figure 1 (b) shows the steel sphere of mass, *M*, displaced so that it makes an angle Θ_1 to the vertical. It is then released and collides with the stationary sphere of mass, *m*. Show that the velocity, u_1, just before impact is given by

$$u_1 = \sqrt{2gl(1 - \cos\theta_1)}$$

[3 marks]

(b) After the collision, mass M swings to an angle Θ_2 and moves mass m up to an angle ϕ. [Figures 1 (b), 1 (c)]

The ratio of the two masses is given by $\dfrac{M}{m} = \dfrac{\sin\frac{\phi}{2}}{\sin\frac{\theta_1}{2} - \sin\frac{\theta_2}{2}}$

(i) Describe how you would carry out the experiment to determine the ratio of the TWO masses. Clearly explain how the values of Θ_1 , Θ_2 and ϕ are obtained.

[5 marks]

(ii) The following results for the positions of the strings were obtained for such an experiment. Calculate the mean values, a_3 and b_2.

a_1 = 3.5 cm, a_2 = 45.5 cm, b_1 = 60.0 cm, d = 50.0 cm

a_3 = 59.3 cm, 59.1 cm, 58.9 cm, 59.4 cm, 59.3 cm, 59.2 cm;

$\therefore$ mean a_3 = ________________________

b_2 = 89.0 cm, 88.8 cm, 91.1 cm, 90.8 cm, 88.5 cm, 89.0 cm;

$\therefore$ mean b_2 = ________________________ **[2 marks]**

(iii) Calculate values of Θ_1 , Θ_2 and ϕ.

Θ_1 = , Θ_2 = , ϕ =

________________ ________________ ________________

[3 marks]

(iv) Hence determine the ratio $\frac{M}{m}$.

[3 marks]

Total 16 marks

GO ON TO THE NEXT PAGE

NOTHING HAS BEEN OMITTED.

2. In the following experiment you are going to determine the angle of minimum deviation and the refractive index of the material of a triangular prism as shown in Figure 2.

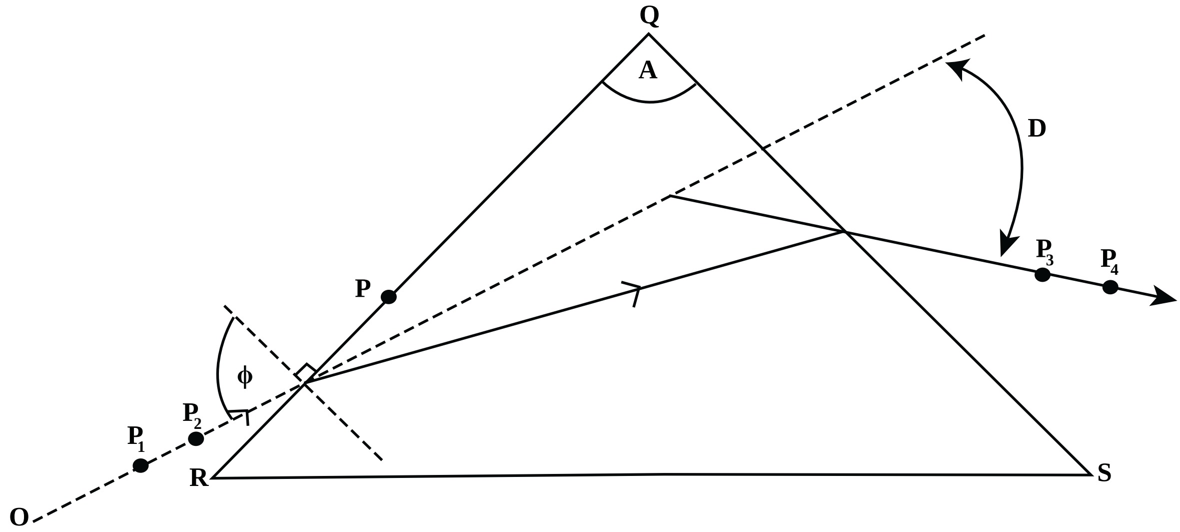


Figure 2

On the blank page insert provided, carefully draw an outline of the triangular prism. Remove the prism.

(a) At a point *P*, about $\frac{2}{3}$ of length *RQ* from *Q*, construct a normal to *RQ*.

Mark off an angle, ϕ, of 20° with this as indicated on the diagram.

[2 marks]

(b) Replace the prism over its outline and place TWO pins, P_1 and P_2, on *OP*. Looking through the face, *QS*, place TWO pins, P_3 and P_4, in such positions as to form a straight line with P_1 and P_2 as seen through the prism. Measure the angle of incidence, ϕ, and the deviation angle, *D*. Repeat the procedure to obtain pairs of corresponding values of ϕ and *D* for a wide range of values of ϕ up to 70°. Record your values in the table below.

TABLE 1

ϕ **(degrees)**	***D*** **(degrees)**
20	

[6 marks]

GO ON TO THE NEXT PAGE

(c) Plot a graph of D against ϕ on page 9. **[5 marks]**

(d) From the graph, determine D_m, the minimum value of D. **[1 mark]**

(e) Using the formula below and the value for D_m obtained from the graph, determine a value for the refractive index of the material of the prism.

$$n = \frac{\sin\left(\frac{A + D_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

[2 marks]

Total 16 marks

NOTHING HAS BEEN OMITTED.

3. Figure 3 shows a constant volume gas thermometer used in an experiment to determine the value of absolute zero in ºC.

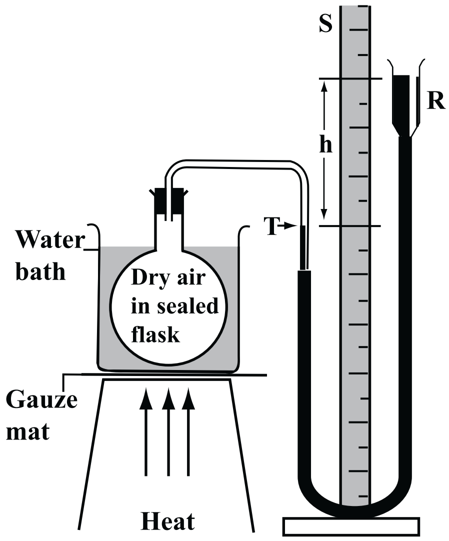


Figure 3 (a)

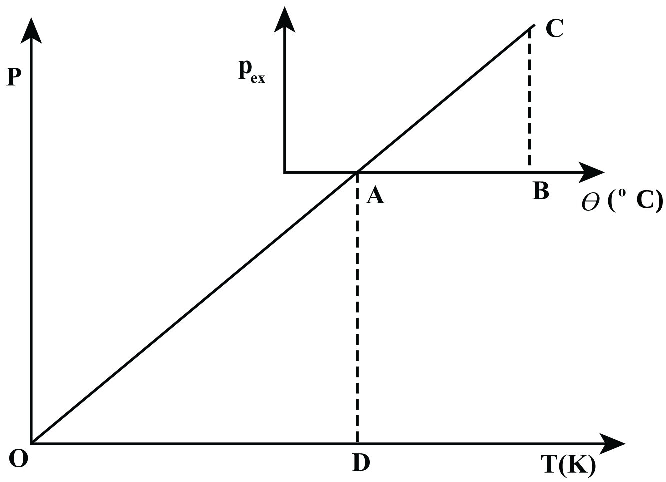


Figure 3 (b)

The bulb was immersed in water and filled with dry air. On the tube, T, there is a mark and by adjusting the level of the mercury reservoir, R, the level of the mercury in T can be adjusted to coincide with this mark. The scale, S, enables one to measure the difference in levels of mercury in the two arms, and so the difference in pressure between the air in the bulb and the outside pressure is known, that is,

$P = P_{at} + P_{ex}$, *where* $P_{ex} = \rho gh$.

In the equation, ρ is the density of mercury, g is the acceleration due to gravity and h is the height of the mercury column as shown. A graph of pressure against absolute temperature should be a straight line through the origin. The graph should therefore resemble that shown in Figure 3 (b).

The small section of the main graph with axes labelled P_{ex} and Θ (ºC) represents data taken from the experiment. Values of excess pressure, P_{ex} and temperature Θ (ºC) obtained from the experiment are given in the table on page 12. *AD* is the pressure at room temperature, that is, atmospheric pressure, and was measured to be 0.76 m Hg. The fixed reading on the left-hand scale, when mercury is up to the mark, was 0.31 m.

From the graph the two triangles *ABC* and *ODA* are similar.

(a) Write an expression for the ratio $\dfrac{OD}{AD}$ in terms of *AB* and *CB*.

____

[2 marks]

GO ON TO THE NEXT PAGE

TABLE 2

Temperature, Θ (°C)	**Right Hand Scale Reading, RHS (m)**	**h (m) RHS - LHS**	**Excess Pressure, $P_{ex} = \rho g h$ (Pa)**
29	0.31	0	0
35	0.33		
40	0.34		
45	0.35		
50	0.36		
55	0.37		
60	0.38		
65	0.39		
70	0.40		
75	0.42		
80	0.43		
85	0.45		

(b) Complete Table 2 by filling in the missing values. **[2 marks]**

(c) Plot a graph of excess pressure, P_{ex}, versus temperature, Θ, on page 13. **[5 marks]**

(d) Use your graph to determine the value of *OD*.

[1 mark]

(e) Hence calculate the value of absolute zero in °C.

[2 marks]

(f) Give TWO possible sources of error in the experiment.

____

____

____

____

[2 marks]

GO ON TO THE NEXT PAGE

(g) Explain how the errors you stated in (f) can be reduced.

____

[2 marks]

Total 16 marks

END OF TEST

TEST CODE **02238020**

FORM TP 2011240

MAY/JUNE 2011

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of **SIX** questions, divided into Sections A and B.
2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.
3. Section B consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.
4. Diagrams may be drawn in pencil but **all writing** must be in **ink**.
5. All working **MUST** be **CLEARLY** shown.
6. The use of silent non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
	$\dfrac{1}{4\pi\varepsilon_0}$	=	9.0×10^{9} m F^{-1}
Elementary charge	e	=	1.60×10^{-19} C
Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Answer ALL questions.

You MUST write your answers in the spaces provided in this answer booklet.

1. (a) Define magnetic flux density, B, in terms of the force on a current-carrying wire.

____

____

____

____

[2 marks]

(b) Figure 1 (b) shows a wire, P, carrying a current perpendicular to the plane of the paper, between two flat permanent magnets which have poles on their faces as shown in Figure 1 (a). Draw the resultant magnetic field pattern between the two magnets. Indicate on the figure, with an arrow labelled M, the direction of motion of the wire.

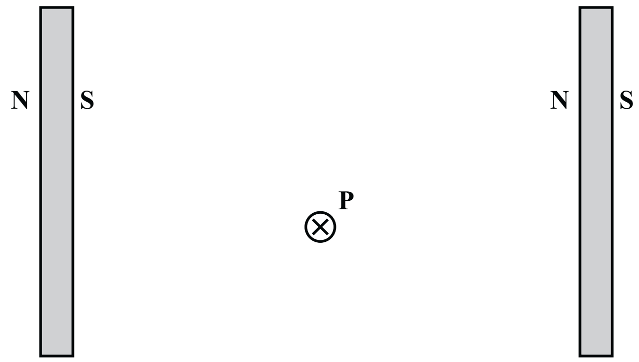


Figure 1 (b)

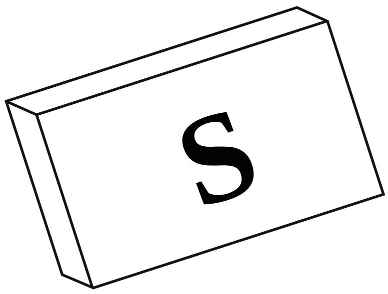


Figure 1 (a)

[4 marks]

(c) Figure 1 (c) shows a narrow beam of electrons travelling at a speed, v, and directed into a uniform electric field between two oppositely charged parallel plates placed a distance, d, apart. The top plate is at a positive potential, V, relative to the lower plate. A magnetic field is now applied perpendicularly to the direction of the electric field between the plates and the deflection of the beam is cancelled.

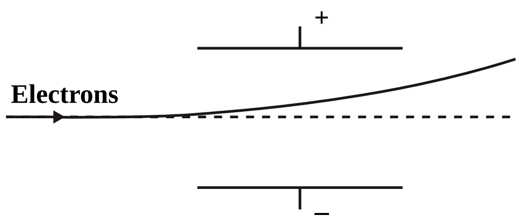


Figure 1 (c)

(i) State the direction of the magnetic field.

____

[1 mark]

(ii) By considering the forces on EACH electron, show that the magnetic flux density is given by

$$B = \frac{V}{vd} \quad .$$

[4 marks]

(iii) Given that $V = 3500$ V, $v = 2.8 \times 10^7$ m s^{-1}, and $d = 50$ mm, calculate the magnetic flux density of the magnetic field.

[2 marks]

(iv) The magnetic flux density is now doubled. The distance between the plates is then adjusted so that no deflection occurs. Calculate the new distance.

[2 marks]

Total 15 marks

2. (a) (i) What does the term 'bistable' mean when used in reference to an electronic circuit?

____

____

[1 mark]

(ii) Figure 2 (a) shows a quad NOR circuit board with l.e.d.'s to show the output of each gate. It is connected to a 6 V battery.

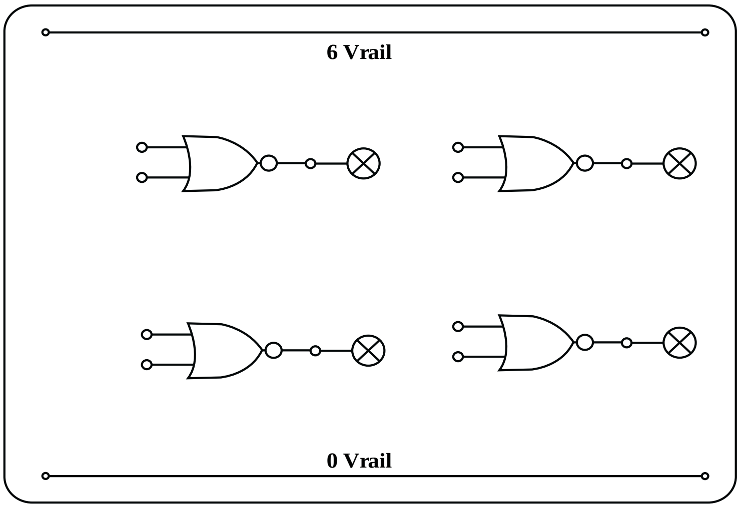


Figure 2 (a)

Draw connecting wires on the diagram to show the construction of an S-R flip-flop with clearly marked inputs I_1 and I_2 and outputs Q and $\overline{Q}$.

A friend asks you to demonstrate how this circuit acts as an electronic latch, perhaps as part of a burglar alarm. Complete the sequential truth table on the right and use it to assist you in describing the connections you would need to make to show this feature to your friend.

	sequence of inputs		outputs	
Row No.	I_1	I_2	**Q**	$\overline{Q}$
1	**0**	**1**		
2	**0**	**0**		
3	**1**	**0**		
4	**0**	**0**		
5	**1**	**0**		
6	**0**	**0**		

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[5 marks]

GO ON TO THE NEXT PAGE

(b) Figure 2 (b) shows two wave forms A and B as inputs to a logic circuit. The resulting output waveform, D, is shown.

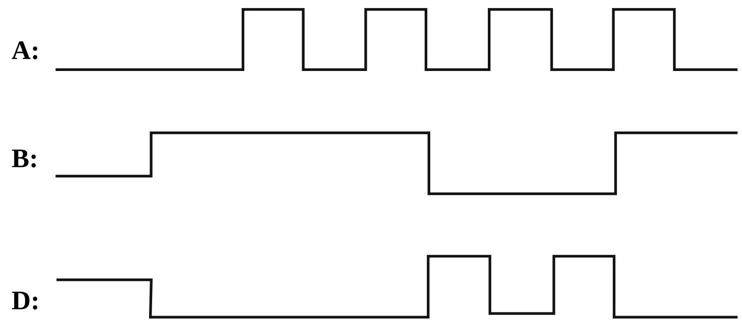

Figure 2 (b)

Draw the truth table for the circuit and hence state the equivalent logic gate for the circuit.

Truth table:

Equivalent logic gate:

____

[4 marks]

GO ON TO THE NEXT PAGE

(c) A 1 kHz square wave of amplitude 5 V is input into one input of an XOR gate while the other input is grounded. An oscilloscope is used to view the output waveform.

(i) What is the frequency of the XOR output?

[1 mark]

(ii) If the same frequency is input but the other input to the XOR is tied to 5 V, what is the frequency of the output?

[1 mark]

(iii) The same square wave is applied to one input of logic gate P while the other input is grounded (See Figure 2 (c) below). The output waveform is a flat line at 0 V. State the name of logic gate P and use a truth table to explain your answer.

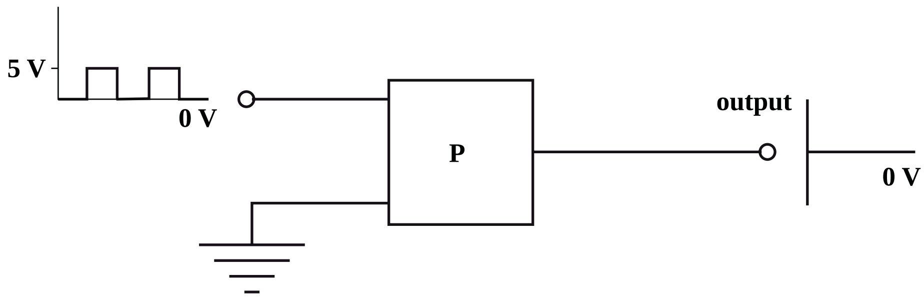

Figure 2 (c)

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

3. (a) In Figure 3 (a), the arrows represent the types of radiation emitted by a radioactive source. The radiation is stopped by the materials shown. Identify EACH type of radiation by writing the name of the radiation next to the arrow that represents the type of radiation.

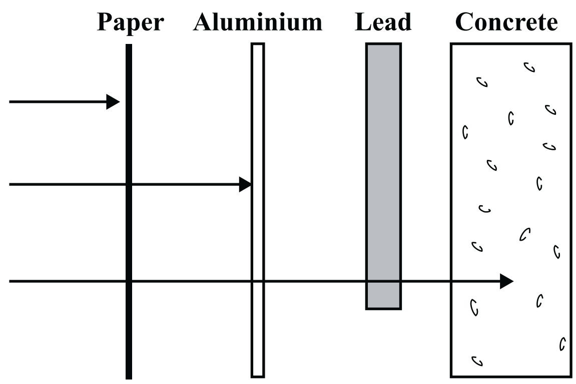

Figure 3 (a)

[3 marks]

(b) Figure 3 (b) shows an arrangement for investigating the variation of intensity of gamma (γ) rays with distance from the small source, S. The distance, d, is taken from two convenient reference points as shown and should be reduced by an amount, *x*, to give the correct distance. The background count of the tube was 27 counts per minute. The count rate is a direct measure of the intensity of the gamma rays.

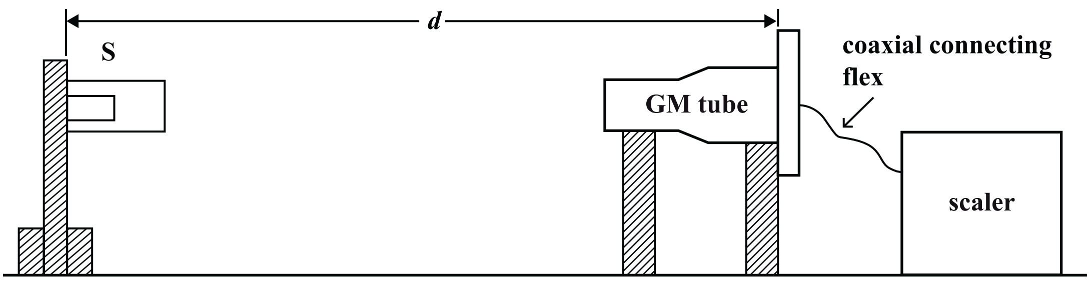

Figure 3 (b)

GO ON TO THE NEXT PAGE

The following results were obtained and are shown in Table 1.

TABLE 1

***d*/cm**	**Count Rate (Counts/min)**	**Corrected Count Rate (C/min)**	$\frac{1}{\sqrt{C}}$
15	2527		
20	1135		
25	652		
30	427		
35	301		
40	235		

The intensity, *C*, of the γ rays is thought to be inversely proportional to the square of the corrected distance, $(d - x)$.

(i) Express this relationship mathematically.

[1 mark]

(ii) Show that a straight line graph would be expected if d were plotted against $\frac{1}{\sqrt{C}}$.

[2 marks]

(iii) Complete Table 1 to show the data that must be plotted to obtain the graph. **[2 marks]**

(iv) On the graph paper provided on page 11, plot the graph. **[5 marks]**

(v) Determine, from the graph, the value of *x*. **[2 marks]**

Total 15 marks

SECTION B

Answer ALL questions.

Write your answers in the spaces provided at the end of the questions.

4. (a) Derive an equation for the equivalent capacitance of **two** capacitors connected in series. **[3 marks]**

(b) A "black box" contains a 4.7 μF capacitor in series with another capacitor with unknown capacitance, *C*. To collect the data for the graph below [Figure 4] it was connected to a battery with emf, *E* and then discharged through a 10 MΩ resistor. Describe, with the aid of a circuit diagram, how the experiment should be performed, assuming any other required apparatus is available in the laboratory. **[4 marks]**

(c) Figure 4 shows a graph depicting the experimental results obtained using the black box for the discharge of the capacitors through the resistor. The decay voltage, *V*, varies with time, *t*, according to the equation

$$V = V_0 exp\left(\frac{-t}{RC_{eq}}\right)$$, where C_{eq} is the capacitance of the two capacitors in series.

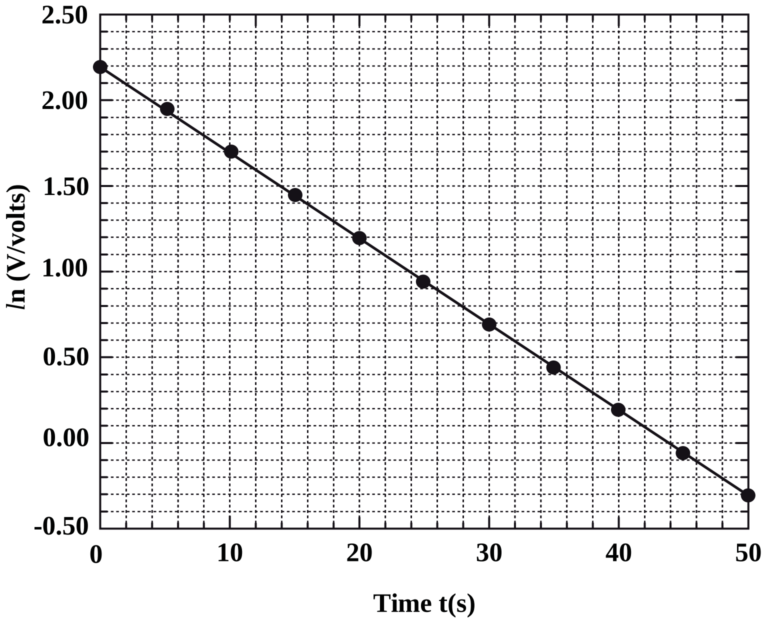

Figure 4

(i) Calculate the gradient of the graph and hence determine the time constant of the circuit. **[4 marks]**

(ii) Calculate the value of the unknown capacitance, *C*. **[3 marks]**

(iii) Determine the value of the unknown source of emf, *E*. **[1 mark]**

Total 15 marks

You MUST write the answer to Question 4 here.

4. (a)

(b)

GO ON TO THE NEXT PAGE

(b)

(c)

5. (a) (i) Explain the terms 'bandwidth' and 'feedback' as applied to operational amplifiers (op-amps). **[2 marks]**

(ii) Figure 5 (a) shows an op-amp on open loop. An alternating sinusoidal voltage of peak-to-peak voltage 2.0 V is applied to the inverting input, with the non-inverting input terminal, Q, connected to earth. The circuit saturates at ±5 V.

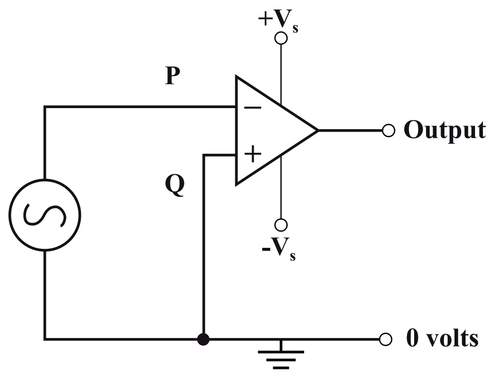

Figure 5 (a)

Sketch, on the same axes, the input waveform and the output waveform produced from this circuit. **[3 marks]**

(iii) The non-inverting input, Q, is then connected to a potential divider and a constant voltage of 0.5 V is applied to Q. Figure 5 (b) shows the output waveform produced by this arrangement.

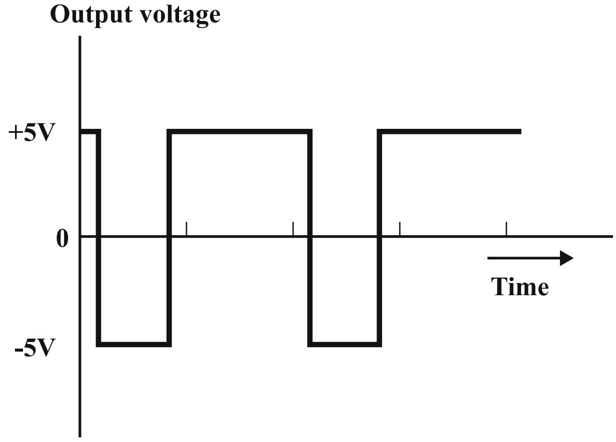

Figure 5 (b)

Explain the shape of this waveform. **[2 marks]**

(b) The circuit in Figure 5 (a) is modified by adding a 2.0 MΩ feedback resistor and a 0.4 MΩ resistor between the inverting input, P, and earth. The a.c. supply unit is disconnected from P and reconnected between Q and earth.

(i) Draw the resulting circuit and state the name of this type of circuit.
[3 marks]

(ii) Calculate the voltage gain of the circuit. **[3 marks]**

(iii) Calculate the MAXIMUM input voltage for no saturation at the output.
[2 marks]

Total 15 marks

You MUST write the answer to Question 5 here.

5. (a) (i) ____

____

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(ii)

(iii)

(b) (i)

(ii)

(iii)

6. (a) (i) Explain what is meant by 'nuclear fission'.

(ii) Sketch a graph to show how the binding energy per nucleon varies with the mass number of the nucleus. Show on the graph the approximate positions of carbon-12 and uranium-235.

(iii) Use your graph to explain why energy is released when a heavy nucleus undergoes fission.

[6 marks]

(b) The fission of 1 kg of uranium-235 releases as much thermal energy as 50 000 kg of oil. 30 MJ of energy is released when 1 kg of oil is burned.

Calculate the mass of fuel used per day, in EACH case, in a 1 000 MW power station which is only 25% efficient and which uses

(i) oil

(ii) uranium. **[8 marks]**

(c) Hence comment on the sustainability of using oil as an energy source for the next century.

[1 mark]

Total 15 marks

You MUST write the answer to Question 6 here.

6. (a)

(b)

(b)

(c)

END OF TEST

TEST CODE **02238032**

FORM TP 2011241

MAY/JUNE 2011

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 2 – Paper 03/2

ALTERNATIVE TO SBA

2 hours

Candidates are advised to use the first 15 minutes for reading through this paper carefully.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of **THREE** questions. Candidates must attempt **ALL** questions.

2. The use of silent non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

1. The voltage, V, across the platinum electrodes in an electrolytic solution of acidified water is related to the current, I, through the solution by the equation $V = \frac{k}{I^n}$ where k and n are constants. You are provided with a beaker of acidified water and two platinum electrodes fixed in position within the beaker.

Design an experiment to determine the constants, k and n.

List of apparatus:

____

____

____

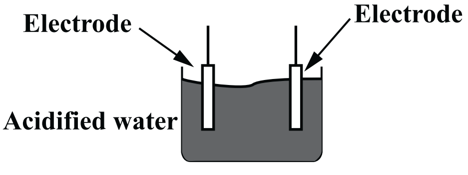
____

____

____

[4 marks]

Complete the circuit diagram (acidified water in beaker and electrodes shown below)



[3 marks]

GO ON TO THE NEXT PAGE

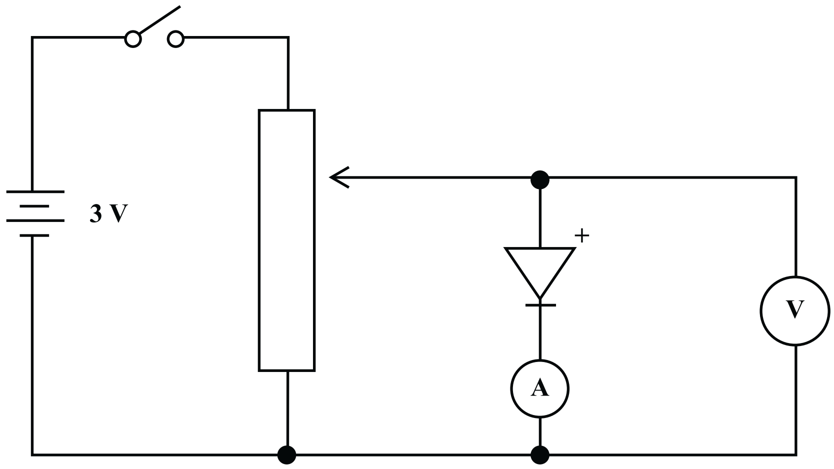
Procedure including precautions taken

[5 marks]

Describe how k and n are determined from the results of the experiment

[4 marks]
Total 16 marks

2. In this experiment you will investigate the properties of a silicon rectifier diode. The circuit to be used is shown below.



(a) Connect the circuit and, **before switching on**, have the supervisor check that it is correct. **[3 marks]**

(b) Use the circuit to obtain values of the current for the voltages shown in the table. **[3 marks]**

p.d. (V)	0.10	0.30	0.50	0.60	0.65	0.70	0.75
I (A)							

(c) On page 5, plot a graph of *I* against p.d. **[7 marks]**

(d) Use your graph to find the resistance of the diode when the p.d. is equal to

(i) 0.25 V

R = ____________________

(ii) 0.58 V

R = ____________________

[3 marks]

Total 16 marks

NOTHING HAS BEEN OMITTED.

3. (a) Radioactivity is an <u>exponential decay</u> and therefore has a constant <u>half-life</u>. Describe an experiment you could perform to show the meaning of the two terms underlined. (A radioactive decay or a simulated radioactive decay would both be acceptable.) Clearly indicate how the results would be processed to reach your conclusion.

[7 marks]

(b) The scintillations of emitted alpha particles on a screen over a large number of equal short time intervals were recorded for a radioactive source. Table 1 shows a set of data for the alpha particle count, c, and the corresponding number of times, n, that count occurred.

TABLE 1

α-particle count, c	0	1	2	3	4	5	6	7	8	9	10	11
Number of times, n	57	203	383	525	408	273	139	45	27	10	4	0

(i) On the graph paper provided on page 9, plot a graph of frequency, n, vs α-particle count, c. **[5 marks]**

(ii) Calculate the mean value of the α-particle count, c.

[3 marks]

(iii) What conclusions can be drawn from the graph about radioactive decay processes?

____

____

[1 mark]

Total 16 marks

END OF TEST

FORM TP 2012237

TEST CODE **02138020**

MAY/JUNE 2012

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 1 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in two sections. Answer ALL questions.
2. For Section A, write your answers in the spaces provided in this booklet.
3. For Section B, write your answers in the spaces provided at the end of each question in this booklet.
4. Diagrams may be drawn in pencil but **all writing** must be in **ink**.
5. All working MUST be CLEARLY shown.
6. The use of silent, non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalized.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
Acceleration due to gravity	g	=	9.80 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^5 N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water		=	1.00×10^3 kg m^{-3}
Specific heat capacity of water		=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice		=	3.34×10^5 J kg^{-1}
Specific latent heat of vaporization of water		=	2.26×10^6 J kg^{-1}
Avogadro's constant	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan-Boltzmann constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in free space	c	=	3.00×10^8 m s^{-1}

SECTION A

Answer ALL questions in this section.

You MUST write your answers in the spaces provided in this booklet.

1. (a) Define the following terms and state which are vectors and which are scalar quantities.

(i) Displacement

(ii) Instantaneous velocity

(iii) Instantaneous acceleration

(iv) Kinetic energy

[6 marks]

(b) Figure 1 shows data related to the displacement of a particle at various times, t. The displacement, x, of the particle is described by the equation,

$$x = x_0 \left(\frac{t}{t_0} \right)^n$$

where x_0 and t_0 are constants.

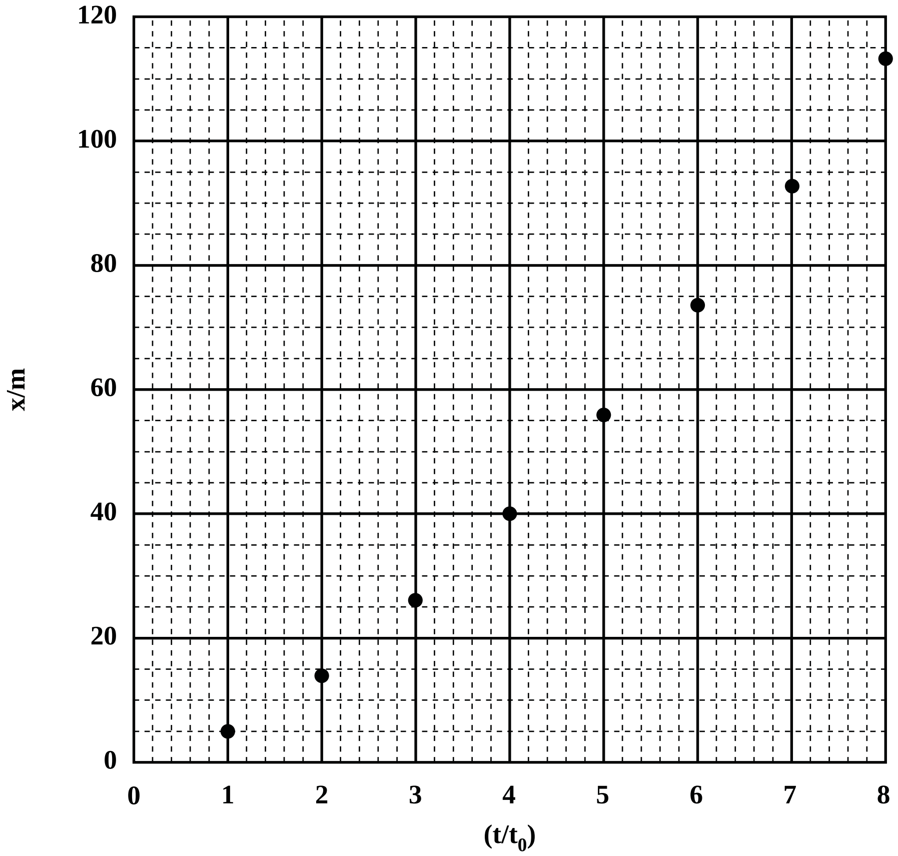


Figure 1

(i) Read off the coordinates of any TWO points from the graph of Figure 1.

[2 marks]

(ii) Use the coordinates from (i) to calculate the value of

a) n

[3 marks]

b) x_0.

[1 mark]

(iii) Given that t_0 = 5 s, determine the velocity of the particle when t = 30 s.

[3 marks]

Total 15 marks

2. (a) A mass, *m*, oscillates on the end of a coiled spring of spring constant, *k*. Write an expression for the period of oscillation, T, of the mass–spring system.

[1 mark]

(b) Figure 2 illustrates a block which can be made to oscillate vertically between two identical springs, each with spring constant, *k*.

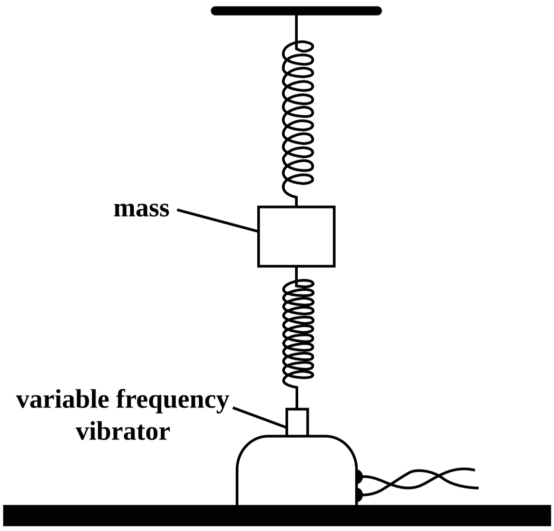


Figure 2

The vibrator has constant amplitude. As the frequency is changed, the amplitude of oscillation of the mass is measured. Table 1 shows the data recorded.

TABLE 1

Frequency, f/Hz	**Amplitude of Vibration of Mass, y/cm**
2.5	1.0
5.0	1.5
7.5	2.5
10	3.8
12.5	4.6
15	3.5
17.5	1.2
20	0.5

(i) On the grid provided on page 7, plot a graph of amplitude of vibration, y, against frequency, *f*. **[5 marks]**

(ii) For the block oscillating at maximum amplitude, determine the

a) angular frequency

[2 marks]

b) period of oscillation.

[1 mark]

(c) The mass of the block is 0.05 kg. Calculate the spring constant, *k*, for ONE of the springs.

[3 marks]

GO ON TO THE NEXT PAGE

(d) (i) A small lump of plasticine is fixed to the mass. On your graph, draw a line to show the possible variation with frequency of the amplitude of the vibration of the combined mass.

[2 marks]

(ii) Briefly describe ONE situation in which it is advantageous to use the phenomenon illustrated in this experiment.

____

____

____

____

[1 mark]

Total 15 marks

3. (a) Write an equation representing the First Law of Thermodynamics and state the meaning of EACH symbol used.

[2 marks]

(b) Table 2 gives data concerning the pressure, P, and volume, V, of a fixed mass of gas as it expands in a cylinder. The temperature of the gas is fixed at 300 K.

TABLE 2

Pressure, $P/10^5$ Pa	**Volume, V/m^3**
4.00	0.001
2.00	0.002
1.35	0.003
1.00	0.004
0.80	0.005

(i) On the grid provided on page 11, plot a graph of pressure, P, against volume, V. **[4 marks]**

(ii) Use your graph to determine the work done by the gas during the expansion. **[3 marks]**

(iii) Write the ideal gas equation and use it to determine the number of moles of gas present.

[3 marks]

(iv) Determine the change in internal energy of the gas.

[1 mark]

(v) Determine the heat supplied to the gas during the expansion.

[2 marks]

Total 15 marks

SECTION B

Answer ALL questions in this section.

Write your answers in the spaces provided at the end of each question.

4. (a) State Newton's 2nd law of motion. **[1 mark]**

(b) A rock of density 2500 kg m^{-3} with volume 0.002 m^3 falls from rest in a viscous medium. The rock is acted on by a net constant downward force of 30 N (a combination of the gravitational force and a buoyant force F_b) and a viscous retarding force F_d, proportional to its velocity, v: $F_d = 5v$.

(i) Draw a free body diagram showing the forces acting on the rock.

(ii) Explain what is meant by a 'viscous medium'. **[2 marks]**

(c) Calculate the

(i) mass of the rock

(ii) buoyant force, F_b

(iii) initial acceleration of the rock

(iv) terminal velocity of the rock. **[10 marks]**

(d) Sketch graphs to show how the (i) velocity and (ii) acceleration of the rock vary with time. **[2 marks]**

Total 15 marks

Write your answer to Question 4 here.

Space for diagram.

Space for graphs.

5. (a) (i) Differentiate between the terms ‘diffraction’ and ‘refraction’.

(ii) Describe how the width of the aperture through which a wave is passing affects the diffraction of the wave.

(iii) Explain how a diffraction grating produces a spectrum. **[6 marks]**

(b) A diffraction grating having 4.55×10^5 lines per metre is used to examine the light from a glowing gas. The first order violet light emerges at an angle of 11.8^o and the first order red light at an angle of 15.8^o.

Calculate the wavelengths of the two colours. **[5 marks]**

(c) With the aid of calculations, determine what would be observed at an angle of 54.8^o. **[4 marks]**

Total 15 marks

Write your answer to Question 5 here.

6. (a) (i) Describe how a physical property of a substance which varies with temperature may be used for the measurement of temperature on an empirical centigrade scale.

(ii) Explain how the absolute thermodynamic scale of temperature differs from that described above.

(iii) Mercury expands only a small amount when it is heated. There are many liquids which expand a great deal more. State ONE reason why mercury is still often used in thermometers. **[6 marks]**

(b) A resistance thermometer is placed in a bath of liquid at $0^{o}C$ and its resistance is found to be 3750 Ω. At $100^{o}C$, its resistance is 215 Ω. The bath is cooled until the resistance is 950 Ω.

(i) Determine the new temperature of the bath, as measured using the resistance thermometer.

(ii) The reading taken at the same time on a mercury-in-glass thermometer placed in the bath is $76^{o}C$. Suggest ONE reason for the difference between this reading and the value calculated above in b (i). **[3 marks]**

(c) Figure 3 shows an electric water heater designed to provide a continuous supply of hot water. Water is flowing at the rate of 0.300 kg min^{-1}, the inlet thermometer registers $20.0^{o}C$, the voltmeter reads 120 V and the ammeter reads 10.0 A.

(i) Calculate the power developed by the heater.

(ii) When a steady state is finally reached, what is the reading on the outlet thermometer?

(iii) State ONE reason why it is NOT necessary to take into account the heat capacity of the apparatus itself. **[6 marks]**

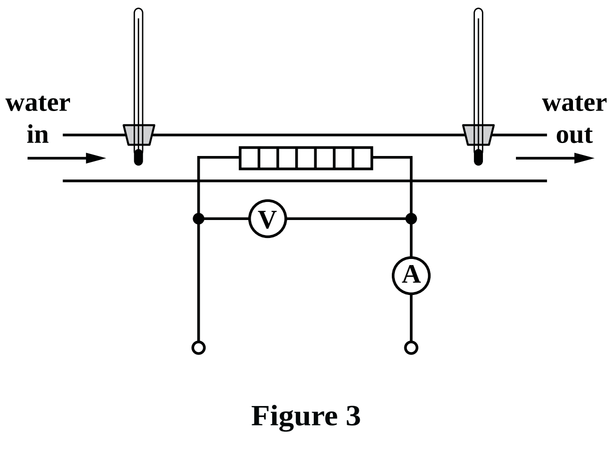


Figure 3

Total 15 marks

Write your answer to Question 6 here.

GO ON TO THE NEXT PAGE

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

FORM TP 2012238

TEST CODE **02138032**

MAY/JUNE 2012

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 1 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of **THREE** questions. Candidates must attempt **ALL** questions.

2. The use of silent non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

3. You are advised to take some time to read through the paper and plan your answers.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

1. You are provided with a metal ball of given diameter, D. Design a ball drop experiment to accurately determine a value for the acceleration due to gravity, g.

List of apparatus:

Diagram of setup:

[7 marks]

Procedure including precautions taken:

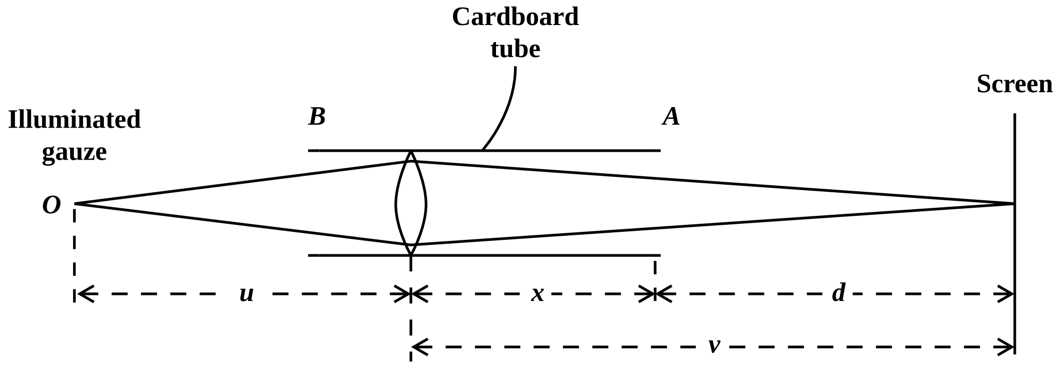
[4 marks]

Processing of results to get the acceleration due to gravity:

[5 marks]

Total 16 marks

2. This experiment is designed to determine the focal length and position of a convex lens mounted in an inaccessible position inside a tube.



(a) Set up the illuminated gauze at a suitable point on the optics bench to act as an object. Mount the tube at different positions from the illuminated gauze and find the position of the sharpest image formed by using the translucent screen.

Measure and record the height, h_o, of the object, that is, the size of the gauze.

h_o = ___________ cm **[1 mark]**

(b) (i) Using a meter rule measure the distance, *d*, of end A from the screen.

(ii) Record the height, h_i, of the image formed on the screen in EACH case and the corresponding value of *d* in the table below.

(iii) Calculate the magnification, *m*, of the image in EACH case and record the values in the table below.

d (cm)	Height of the image on the screen, h_i (cm)	Magnification, *m*

[4 marks]

GO ON TO THE NEXT PAGE

(c) Using the equation $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ it can be shown that the magnification, *m*, of the image is given by $m = \frac{1}{f} \cdot d + \left(\frac{x}{f} - 1\right)$

(i) On the grid provided on page 5, plot a graph of *m* against *d*. **[5 marks]**

(ii) Calculate the gradient of your graph.

[2 marks]

(iii) Determine the focal length, *f*, of the lens.

[2 marks]

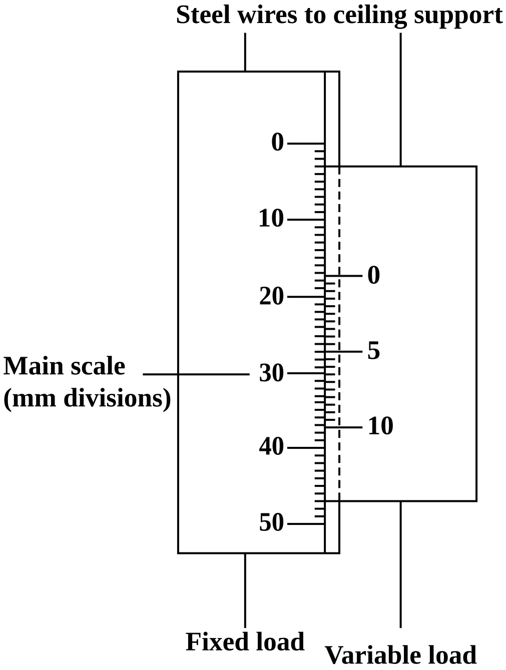
(iv) Calculate the value of *x*, the distance of the lens from end A of the tube.

[2 marks]

Total 16 marks

3. (a) The measuring instruments below were used to measure quantities in an experiment to determine the Young's modulus of steel in the form of a long straight wire.

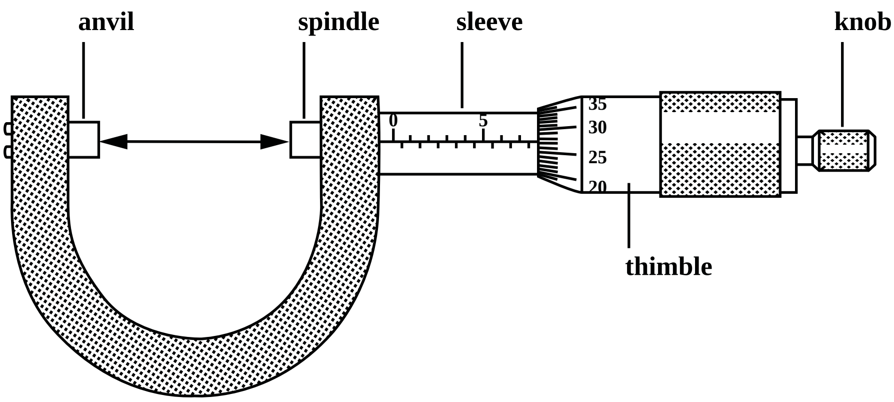
State the name of EACH measuring instrument and read off the values indicated on the measuring instruments.



Name: ____________________

Reading = ____________________

[2 marks]



Name: ____________________

Reading = ____________________

[2 marks]

(b) The following data was obtained in the experiment to determine the Young's modulus of a metal in the form of a long wire. The natural length of the wire is 1.50 m. The average value of the diameter, D, of the wire is 0.40 ± 0.01 mm.

Load, N	Extension, $\times 10^{-4}$ m
5	3.0
10	6.0
15	9.0
20	11.0
25	12.0
30	14.0
35	17.0
40	19.0
45	21.0
50	24.0

(i) Calculate the cross sectional area, A, of the wire using the formula, $A = \frac{\pi D^2}{4}$.

[1 mark]

(ii) Determine the relative percentage error in A.

[2 marks]

(iii) On the grid provided on page 9, plot a graph of load against extension for the wire. **[5 marks]**

(iv) Using the gradient of the graph, determine the value of the Young's modulus for the wire.

[4 marks]

Total 16 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

FORM TP 2012240

TEST CODE **02238020**

MAY/JUNE 2012

C A R I B B E A N E X A M I N A T I O N S C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in two sections. Answer ALL questions.
2. For Section A, write your answers in the spaces provided in this booklet.
3. For Section B, write your answers in the spaces provided at the end of each question in this booklet.
4. Diagrams may be drawn in pencil but **all writing** must be in **ink**.
5. All working MUST be CLEARLY shown.
6. The use of silent, non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalized.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$\frac{1}{4\pi\varepsilon_0} = 9.0 \times 10^{9}$ m F^{-1}
Elementary charge	e	=	1.60×10^{-19} C
Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
(Energy equivalence:	$1u$	=	931 MeV/c^{2})
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Answer ALL questions in this section.

You MUST write your answers in the spaces provided in this booklet.

1. (a) Figure 1 shows a current balance used to determine the field between the poles of a permanent magnet. A current from the power supply flows through the pivots P, P' to the horizontal wire, AB, which experiences a downward force, F. This force is balanced by the torque caused by the weight, mg, of a small movable "slider".

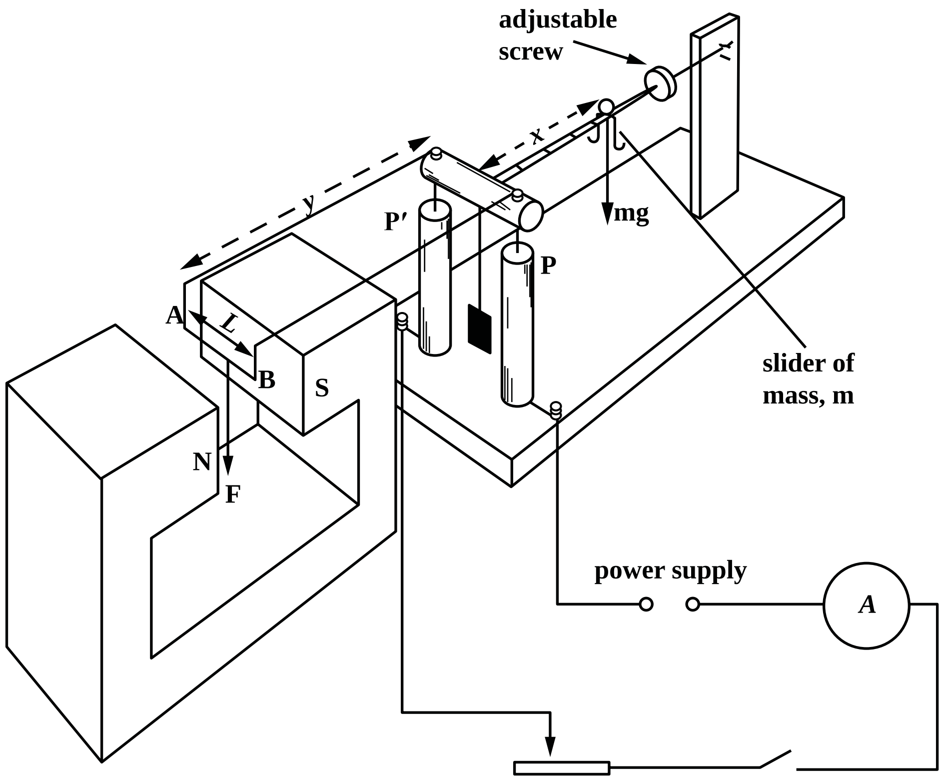
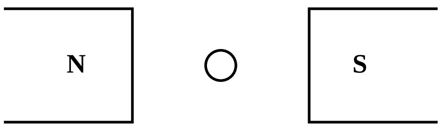


Figure 1

(i) Mark on Figure 1 the direction of the current through the portion of the wire AB of the circuit and state the name of the rule used to determine the direction of the flow of current.

(ii) Show, on the diagram below, the field lines between the poles of the magnet when the current is flowing in AB.



[3 marks]

(b) (i) Show that at equilibrium, the current through the circuit is given by

$I = \frac{mgx}{BLy}$, where L is the length of wire, AB.

(ii) Describe how the apparatus would be used to obtain a set of readings for I and x, clearly stating how the results are taken.

____

____

____

____

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____

[6 marks]

(c) Figure 2, on page 5, shows a graph of the data obtained for the current I/A versus position x/m.

(i) Draw the best straight line through the data.

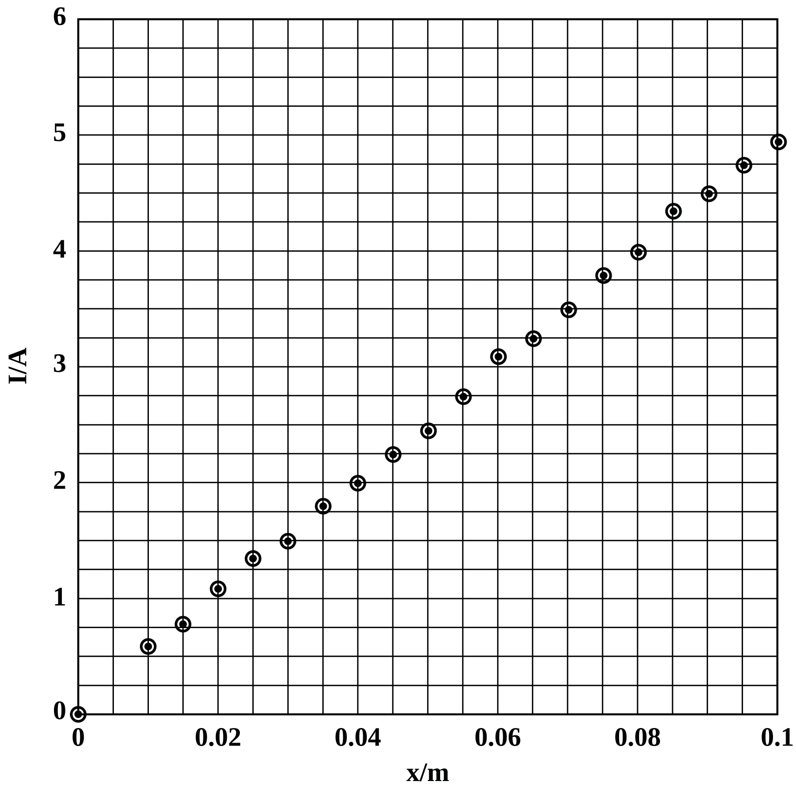


Figure 2

(ii) Determine the gradient of the best line drawn.

(iii) Given that l = 2.0 cm, L = 5.0 cm, m = 0.50 g, calculate the value of the magnetic flux density, B, for the magnet.

[6 marks]

Total 15 marks

2. This question refers to the plotting of the transfer characteristic of a non-inverting amplifier.

(a) (i) Add a resistor to the op-amp circuit below [Figure 3] so that it becomes a non-inverting amplifier with a theoretical gain of +10. Label it with the value of the required resistance.

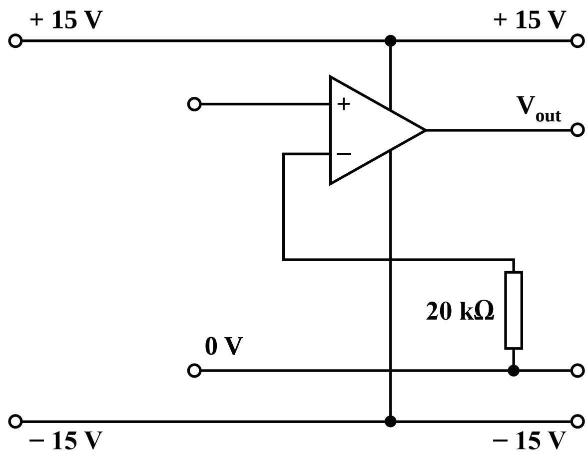


Figure 3

(ii) Show on Figure 3 how meters and a potential divider would be connected to enable the data like that in Table 1 to be collected. **[6 marks]**

(b) (i) On the grid provided on page 7, use the data below to plot the characteristic (V_{out} vs V_{in}) for a non-inverting amplifier similar to the one in (a) above.

TABLE 1

V_{in} / V	V_{out} / V	V_{in} / V	V_{out} / V
3.00	12.90	0.18	1.74
2.60	12.90	–0.59	–5.82
2.30	12.90	–0.98	–9.72
1.90	12.90	–1.18	–11.70
1.22	12.10	–1.60	–13.80
1.05	10.40	–1.90	–13.80
0.73	7.27	–2.60	–13.80
0.56	5.50	–3.30	–13.80

(ii) From the graph, determine, to 3 significant figures, the gain of the amplifier. **[9 marks]**

Total 15 marks

NOTHING HAS BEEN OMITTED.

3. (a) (i) State the name of the scientist who is credited with the explanation of the photoelectric effect.

____

(ii) With reference to the photoelectric effect, explain what is meant by

a) 'threshold frequency'

____

____

b) 'work function'.

____

____

[3 marks]

(b) Figure 4 shows a circuit used in an experiment to investigate the photoelectric effect from a metal. Table 2 shows data obtained from such an experiment.

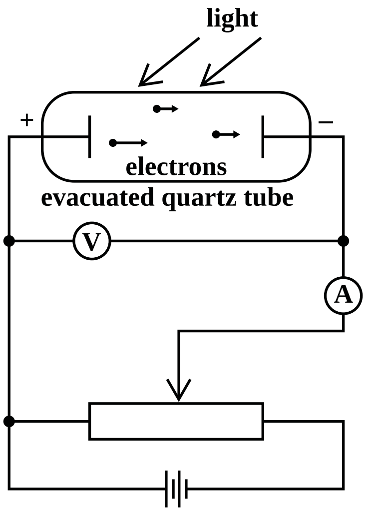


Figure 4

GO ON TO THE NEXT PAGE

TABLE 2

Wavelength λ**/nm**	**Frequency,** $f \times 10^{14}$ **Hz**	**Stopping Potential** V_s**/volt**
544	5.51	0.360
594		0.199
604	4.97	0.156
612		0.117
633	4.74	0.062

(i) Fill in the missing values in Table 2. **[1 mark]**

(ii) On the grid provided on page 11, plot a graph of stopping potential energy versus frequency for the metal. **[4 marks]**

(iii) Use your graph to determine the values given by this data for

a) Planck’s constant

[4 marks]

b) the work function of the metal.

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

SECTION B

Answer ALL questions in this section.

Write your answers in the spaces provided at the end of each question.

4. (a) (i) Define the terms 'capacitance' and 'farad'.

(ii) Write an expression for the net capacitance of three capacitors of capacitance C_1, C_2, C_3 connected in

a) series

b) parallel.

(iii) State what is meant by the term 'time constant' for a capacitor discharge circuit.

[5 marks]

(b) Figure 5 shows a circuit diagram for a highway emergency flasher that uses a 120 V battery, a 1.0 MΩ resistor, a 1.0 μF capacitor and a neon flash lamp. The flash lamp has a resistance of more than 1×10^7 Ω when the voltage across it is less than 110 V. Above 110 V, the neon gas ionizes, the resistance of the lamp drops to 10 Ω and the capacitor then discharges completely in **three time constants** of the discharge circuit.

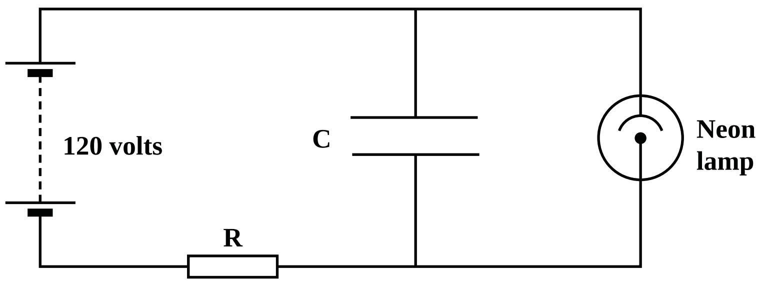


Figure 5

(i) Calculate EACH of the following:

a) The time between flashes, that is, the time it takes for the uncharged capacitor to reach a p.d. of 110 V

[The formula for the charging of a capacitor is $V = V_o\,(1 - e^{\frac{-t}{RC}})$]

b) The duration of each flash

c) The energy released in each flash **[6 marks]**

(ii) It is claimed that during the flash, the light is as bright as that from a 200 W light bulb. Comment on this statement. **[4 marks]**

Total 15 marks

GO ON TO THE NEXT PAGE

Write your answer to Question 4 here.

5. Figure 6 shows the variation with frequency, *f*, of the voltage gain, G, without feedback, of an operational amplifier (op-amp).

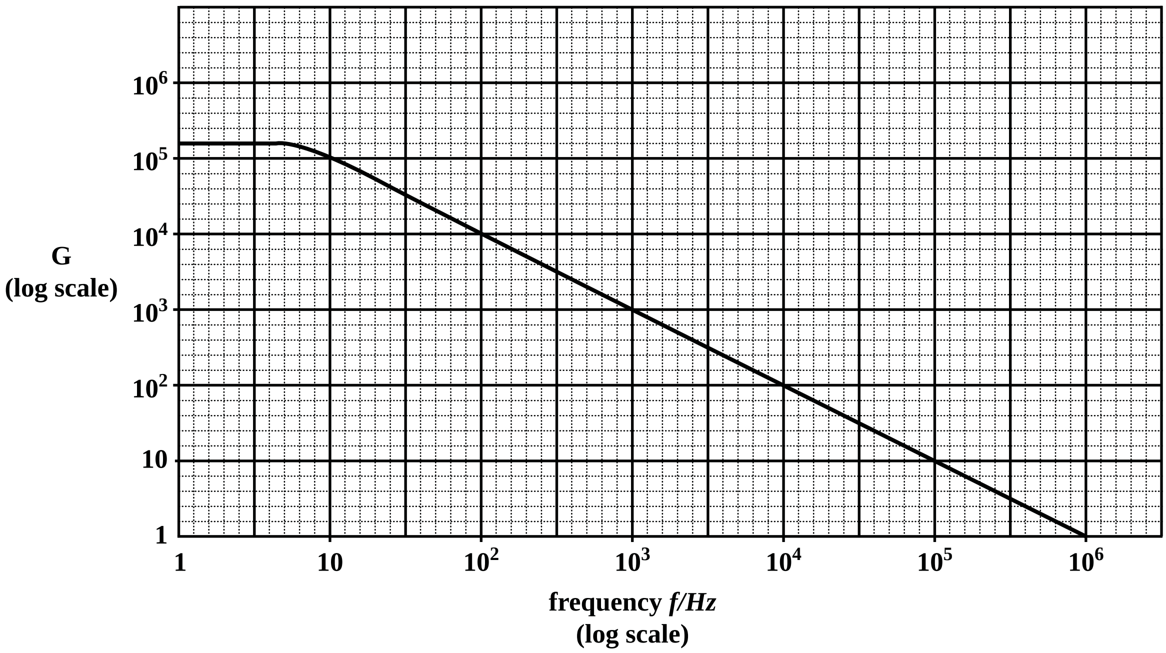


Figure 6

The op-amp is used in the circuit shown in Figure 7.

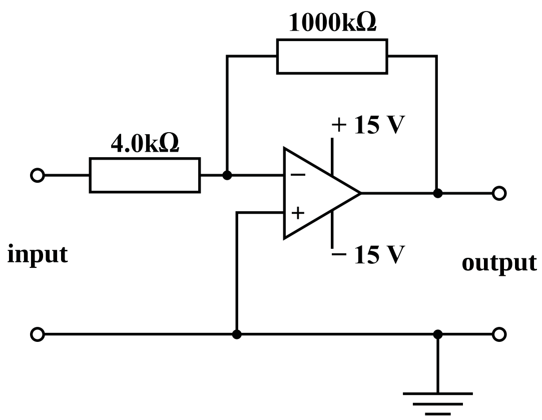


Figure 7

(a) State

(i) the type of amplifier circuit shown in Figure 7

(ii) what is meant by 'negative feedback' in this amplifier. **[2 marks]**

(iii) Calculate

a) the gain of this amplifier at low frequencies

b) the bandwidth of the amplifier. **[5 marks]**

(iv) What is the peak output voltage for an input signal of peak value 0.052 V and frequency 1.0×10^4 Hz? **[2 marks]**

(b) Figure 8 shows a digital circuit with inputs A and B.

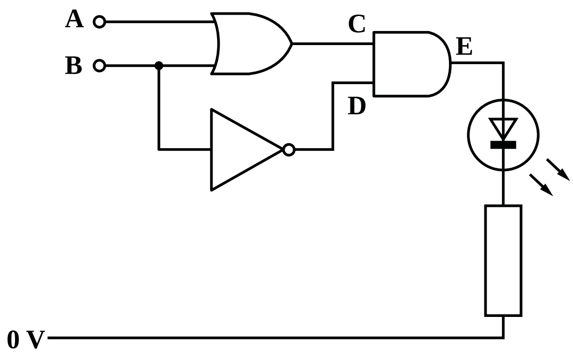


Figure 8

(i) Copy and complete the truth table (Table 3) for the circuit shown in Figure 8.

TABLE 3

A	B	C	D	E
0	0			
0	1			
1	0			
1	1			

[3 marks]

(ii) The circuit of Figure 8 is modified so that inputs A and B are controlled by a thermistor, R_T, and an LDR, R_L, as shown in Figure 9. The thermistor has a negative temperature coefficient and the resistance of R_L is high when in darkness and low when in light.

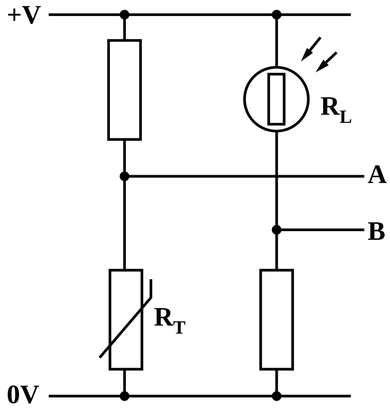


Figure 9

a) The logic state at A changes when R_T is cooled. State whether R_T is hot or cold for logic 1 at A.

b) The logic state at B changes when R_L is put in darkness. State whether R_L is in light or darkness for logic 1 at B.

c) Hence, deduce the environmental conditions for the LED to be conducting.

[3 marks]

Total 15 marks

Write your answer to Question 5 here.

6. (a) (i) Radon has the nuclear formula $^{226}_{86}\text{Rn}$. State the number of protons, neutrons and electrons that are in the neutral atom.

(ii) Explain what is meant by the term ‘isotope’. **[4 marks]**

(b) Define the terms ‘half-life’ and ‘decay constant, λ’ for a radioactive nucleus. Write an equation relating the two quantities. **[3 marks]**

(c) A radioactive sample contains 3.50 μg of pure $^{11}_{6}\text{C}$, which has a half-life of 20.4 minutes.

Determine the

(i) number of nuclei in the sample at t = 0

(ii) decay constant of the sample

(iii) activity of the sample at t = 0

(iv) activity of the carbon-11 after 8 hours. **[8 marks]**

Total 15 marks

Write your answer to Question 6 here.

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

TEST CODE **02238032**

FORM TP 2012241

MAY/JUNE 2012

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 2 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of **THREE** questions. Candidates must attempt **ALL** questions.

2. The use of silent non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

3. You are advised to take some time to read through the paper and plan your answers.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

1. (a) Setup the circuit shown in Figure 1, close switch S and let the capacitor charge for about 1 minute. Open S so that the capacitor discharges. Start timing at 20s intervals and record observations in the table below.

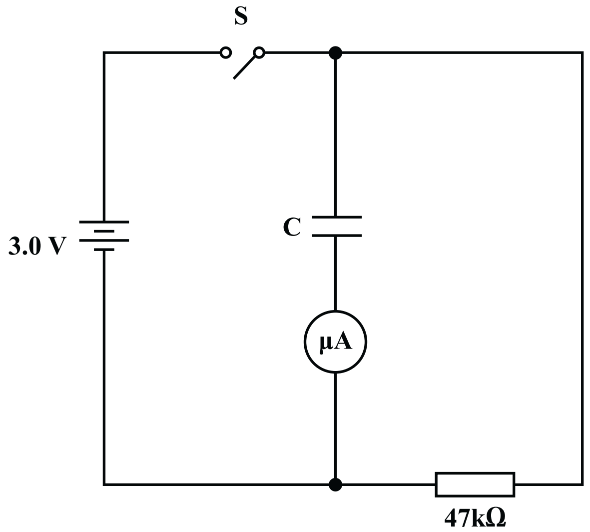


Figure 1

t/s	I/μA	ln(I/μA)
0		

[4 marks]

(b) The current through the ammeter obeys the relation $I = I_0 e^{-t/RC}$. Show how a straight line graph can be obtained from this relation.

[1 mark]

(c) (i) On the grid provided on page 3, plot a graph of ln(I/μA) versus t/s. **[5 marks]**

(ii) Determine the gradient of the graph, stating the appropriate units.

[3 marks]

(iii) Determine the value of the unknown capacitor, C, in the circuit.

[3 marks]

Total 16 marks

GO ON TO THE NEXT PAGE

NOTHING HAS BEEN OMITTED.

2. (a) Connect the circuit of the inverting amplifier as shown in Figure 2.

A data sheet with the pin-outs of the 741 Op-amp is provided, if required.

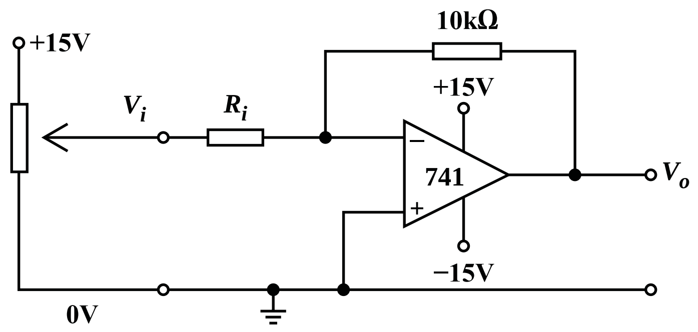


Figure 2

[2 marks]

(b) The input resistor, R_i , is an unknown resistance whose value has to be determined. The feedback resistance, R_f, is to be set at 10 kΩ.

(i) Using the meters provided, take at LEAST six different measurements of the input voltage V_i and the corresponding output voltage V_o. Make sure to keep the output voltage, V_o, below the saturation level.

Input voltage, V_i (Volts)	**Output voltage, V_o (Volts)**

[2 marks]

(ii) Measure and record the input voltage at which saturation of the circuit occurs.

____

[1 mark]

(c) (i) On the grid provided on page 7, plot a graph of V_o against V_i. **[4 marks]**

GO ON TO THE NEXT PAGE

(ii) Use your graph to determine the closed loop gain, A, of the inverting amplifier circuit.

[3 marks]

(iii) Determine the value of the unknown resistor, R_i, in the circuit.

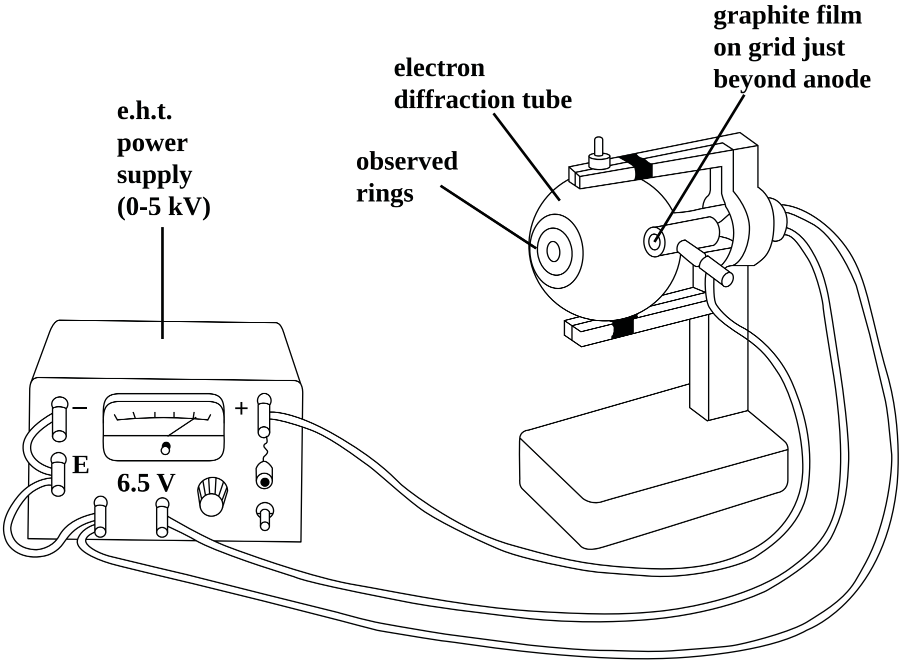
[2 marks]

(d) Calculate the theoretical value of the input voltage, V_i, at which the circuit becomes saturated.

[2 marks]

Total 16 marks

3. (a) The following setup is used to investigate the diffraction of electrons. A beam of electrons is accelerated through an accelerating potential V_s in an evacuated tube and hits a graphite film to produce a system of concentric rings on the screen.



What evidence does electron diffraction provide about the nature of electrons?

____

____

[1 mark]

GO ON TO THE NEXT PAGE

(b) The inner diameter of a ring so formed was carefully measured as the accelerating potential V_s was slowly increased to a maximum of 5 kV. Table 1 shows the data obtained.

TABLE 1

Accelerating Potential, V_s/ V	**Inner Diameter of Ring, D/m**	**$1/\sqrt{V_s}$**
2500	0.0897	
3000	0.0819	
3500	0.0758	
4000	0.0709	
4500	0.0669	
5000	0.0634	

(i) State the instrument that may be used to accurately measure the diameter of the ring.

[1 mark]

(ii) State the reason why the inside of the tube is coated with a fluorescent material.

[1 mark]

(iii) Complete Table1 by filling in the empty column. **[2 marks]**

(iv) On the grid provided on page 11, plot a graph of the inner diameter D versus $1/\sqrt{V_s}$. Draw the best straight line through the points. **[5 marks]**

(c) (i) Calculate the gradient of the graph, clearly stating its units.

[3 marks]

(ii) Given that $D = \dfrac{8.33\times10^{23}}{d\sqrt{V_s}}\cdot h$, where $d = 0.123\times10^{-9}$ m, use your answer in c (i) to determine a value for Planck's constant, h.

[3 marks]

Total 16 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

FORM TP 2012238 – IS

TEST CODE **02138032 – IS**

MAY/JUNE 2012

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 1 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

23 MAY 2012 (a.m.)

INSTRUCTIONS FOR SETTING UP THE ALTERNATIVE TO SCHOOL-BASED ASSESSMENT EXAMINATION

Instructions:

Question 1

None

Question 2

Apparatus required:

For EACH candidate:

1. A lamp, with a suitable power supply.

2. A screen with a piece of gauze to act as an object. The gauze should be about 1 cm in diameter.

3. Converging lens mounted in a cardboard box. A tube 8 cm long cut from a hand towel roll would be suitable. The lens should have a focal length of about 15 cm and NOT be mounted at the centre of the tube.

3. Simple optical bench to mount components (or two metre rules taped to the table).

4. White or translucent screen.

The experiment should be performed in a section of the laboratory where there is dim light.

In the experiment the candidate is required to place the lamp, gauze, tube and screen on the optical bench then move the tube and screen so that a sharp image of the gauze is formed on the screen. The Supervisor should ensure that various components are mounted at the correct height to obtain a clear image.

Question 3

None

END OF INSTRUCTIONS

TEST CODE **02138032 – SR**

FORM TP 2012238 – SR

MAY/JUNE 2012

SCHOOL/CENTRE NUMBER					

NAME OF SCHOOL/CENTRE

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 1 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

23 MAY 2012 (a.m)

SUPERVISOR'S REPORT ON THE ALTERNATIVE TO SCHOOL-BASED ASSESSMENT EXAMINATION

When completed, this report MUST accompany candidates' answer booklets for the Alternative to School-Based Assessment Examination.

SUPERVISOR'S NAME
(Please print)

____

SUPERVISOR'S SIGNATURE

____

The attention of supervisors is drawn to the following:

(a) ASSISTANCE TO CANDIDATES

Candidates MUST be told before the test begins that:

(i) Help will be available to those candidates who need it in order to proceed with the experiment, but that such help will be given to a candidate only if he/she requests it. Assistance should be confined to guidance in setting up apparatus or describing procedure to enable candidates to obtain readings. Help with the interpretation of graphs, the determination of gradients or calculations and formulae is NOT to be given.

(ii) Wherever such assistance is given, a full report must be submitted to the examiners of the nature and extent of it.

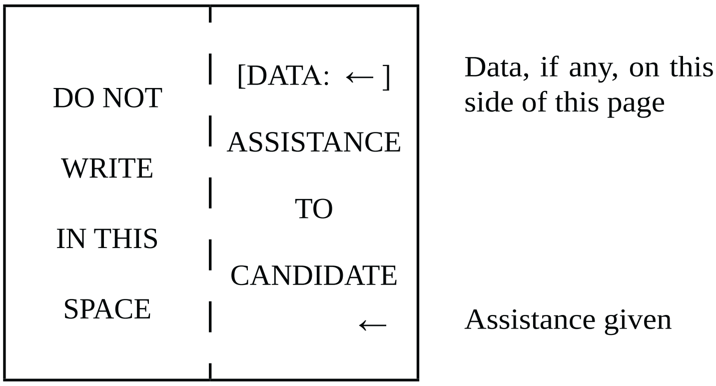
(iii) Candidates who receive help are liable to suffer a loss of marks.

Supervisors will appreciate the need for such reports to be accurate if candidates who receive help are to be fairly assessed. They are therefore requested in submitting their reports to state the nature and extent of the assistance given in the space allotted in the candidate's answer booklet (see diagram in (b) below), and also in the space provided on page 5 in this report form. In any report it is important to include the candidate's number as well as name.

N.B. Help is not to be offered to any candidate.

(b) DATA TO BE SUPPLIED TO CXC

Data are to be supplied on this report form in the space provided. In addition, they should be given on the right-hand half of the inside of the front cover of each candidate's answer booklet. (See diagram below.) This should be done only AFTER THE COMPLETION OF THE EXAMINATION.



FRONT INSIDE COVER OF ANSWER BOOKLET

(c) Only apparatus stipulated in the "Instructions to Supervisors" booklet is to be supplied to the candidate. The issue of additional equipment or apparatus is NOT allowed.

(d) The declaration form on page 6 is to be signed as indicated before this report is submitted.

GO ON TO THE NEXT PAGE

Information required from supervisor:

Question 1

None

Question 2

Focal length of lens.

Distance of the lens from each end of the box.

Height of object (gauze).

Question 3

None

General Remarks. Here the Supervisor may give an account of any incident(s) which he/she thinks should be communicated to the examiners, in order that they may fairly assess the performance of the candidate and the quality of his/her work.

Report on Assistance Given. (If necessary, continue on page 6.)

Declaration: (Delete as appropriate).

I/We declare that NO assistance was given to any candidate during the examination.

I/We declare that ALL assistance given during the examination has been reported above.

Teacher's Signature | Supervisor's Signature

. . . .

Date: . . . .

FORM TP 2012241 – IS

TEST CODE **02238032 – IS**

MAY/JUNE 2012

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 2 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

14 MAY 2012 (a.m.)

INSTRUCTIONS FOR SETTING UP THE ALTERNATIVE TO SCHOOL-BASED ASSESSMENT EXAMINATION

Instructions:

Question 1

Apparatus required:

For EACH candidate:

One covered 2200 μF capacitor **(Candidates must NOT be given the value of the capacitor).**

One 47 kΩ resistor, labelled 47 kΩ

One switch

Connecting wires

One 3 V battery

One Digital multimeter (Range 0–100 μA)

One Stopwatch

Question 2

Apparatus required:

For EACH candidate:

One 741 Operational Amplifier or similar

One 741 Op-amp data sheet showing pinouts and wiring configurations; if required.

One electronic breadboard/project board with DC +15 V and –15 V connections or other circuit board to enable the candidate to set up an inverting amplifier

Two digital multimeters (0 – 20 V)

Dual voltage $\pm$15 V supply for Op-amp.

Potential divider to vary the input voltage.

One 10 kΩ standard resistor

One 5 kΩ standard resistor*

* The 5 kΩ standard resistor should be covered with a sheath, or painted with ink out so that the candidate cannot read the resistor code.

Question 3

None

END OF INSTRUCTIONS

FORM TP 2012241 – SR

TEST CODE **02238032 – SR**

MAY/JUNE 2012

SCHOOL/CENTRE NUMBER					

NAME OF SCHOOL/CENTRE

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 2 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

14 MAY 2012 (a.m.)

SUPERVISOR'S REPORT ON THE ALTERNATIVE TO SCHOOL-BASED ASSESSMENT EXAMINATION

When completed, this report MUST accompany candidates' answer booklets for the Alternative to School-Based Assessment Examination.

SUPERVISOR'S NAME
(Please print)

SUPERVISOR'S SIGNATURE

____

____

The attention of supervisors is drawn to the following:

(a) ASSISTANCE TO CANDIDATES

Candidates MUST be told before the test begins that:

(i) Help will be available to those candidates who need it in order to proceed with the experiment, but that such help will be given to a candidate only if he/she requests it. Assistance should be confined to guidance in setting up apparatus or describing procedure to enable candidates to obtain readings. Help with the interpretation of graphs, the determination of gradients or calculations and formulae is NOT to be given.

(ii) Wherever such assistance is given, a full report must be submitted to the examiners of the nature and extent of it.

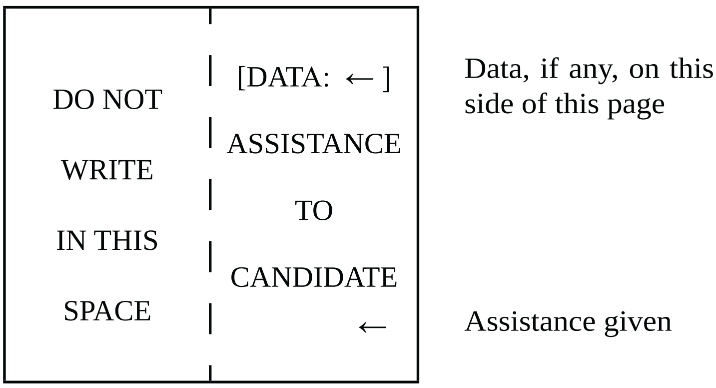
(iii) Candidates who receive help are liable to suffer a loss of marks.

Supervisors will appreciate the need for such reports to be accurate if candidates who receive help are to be fairly assessed. They are therefore requested in submitting their reports to state the nature and extent of the assistance given in the space allotted in the candidate's answer booklet (see diagram in (b) below), and also in the space provided on page 5 in this report form. In any report it is important to include the candidate's number as well as name.

N.B. Help is not to be offered to any candidate.

(b) DATA TO BE SUPPLIED TO CXC

Data are to be supplied on this report form in the space provided. In addition, they should be given on the right-hand half of the inside of the front cover of each candidate's answer booklet. (See diagram below.) This should be done only AFTER THE COMPLETION OF THE EXAMINATION.



FRONT INSIDE COVER OF ANSWER BOOKLET

(c) Only apparatus stipulated in the "Instructions to Supervisors" booklet is to be supplied to the candidate. The issue of additional equipment or apparatus is NOT allowed.

(d) The declaration form on page 6 is to be signed as indicated before this report is submitted.

GO ON TO THE NEXT PAGE

Information required from supervisor:

Question 1

Exact values if not 2200 μF, 47 kΩ

Question 2

Details of circuit board provided.

Question 3

General Remarks. Here the Supervisor may give an account of any incident(s) which he/she thinks should be communicated to the examiners, in order that they may fairly assess the performance of the candidate and the quality of his/her work.

Report on Assistance Given. (If necessary, continue on page 6.)

GO ON TO THE NEXT PAGE

Declaration: (Delete as appropriate).

I/We declare that NO assistance was given to any candidate during the examination.

I/We declare that ALL assistance given during the examination has been reported above.

Teacher’s Signature Supervisor’s Signature

. . . .

Date: . . . .

TEST CODE **02138020**

FORM TP 2013239

MAY/JUNE 2013

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 1 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in TWO sections. Answer ALL questions.
2. For Section A, write your answers in the spaces provided in this booklet.
3. For Section B, write your answers in the spaces provided at the end of each question in this booklet.
4. All working MUST be shown.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

NOTHING HAS BEEN OMITTED.

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
Acceleration due to gravity	g	=	9.80 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^5 N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water	ρ	=	1.00×10^3 kg m^{-3}
Specific heat capacity of water	C_w	=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice	L_f	=	3.34×10^5 J kg^{-1}
Specific latent heat of vaporization of water	L_v	=	2.26×10^6 J kg^{-1}
Avogadro's constant	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan-Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in free space	c	=	3.00×10^8 m s^{-1}
Planck's constant	h	=	6.626×10^{-34} Js

SECTION A

Answer ALL questions.

Write your answers in the spaces provided in this booklet.

1. (a) A ball of mass 1 kg is dropped from a height of *h* metres above the ground. The velocity, *v*, of the ball on its downward journey, is measured for various values of time, *t*. Table 1 shows the variation of velocity with time up to the point when the ball hits the ground.

TABLE 1

Velocity v/m s^{-1}	**Time** t/s
0	0
	1.0
	2.0
	3.0
	4.0

(i) Complete Table 1 by inserting the missing values. **[1 mark]**

(ii) On the grid provided on page 5, plot a graph of velocity, *v*, against time, *t*. **[4 marks]**

(iii) Using your graph, calculate the height, *h*, above the ground from which the ball was dropped.

\

[2 marks]

GO ON TO THE NEXT PAGE

GO ON TO THE NEXT PAGE

(b) A student standing on top of a cliff throws a stone with initial velocity, v_i, at an angle, θ, to the horizontal as shown in Figure 1.

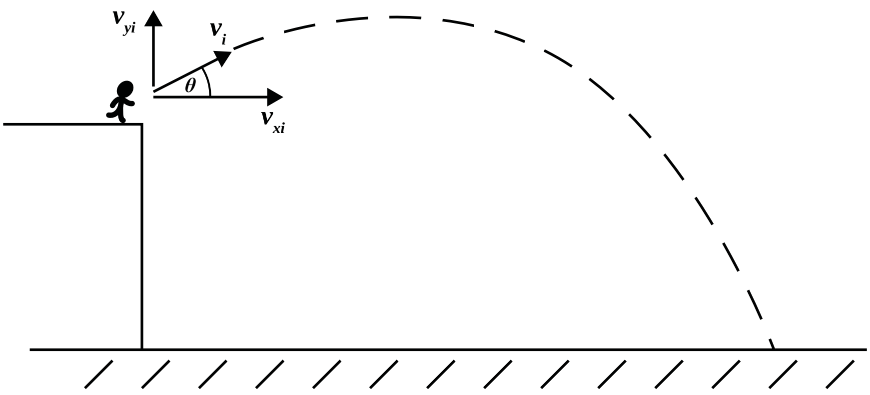


Figure 1

(i) Write expressions for the initial vertical and horizontal components of velocity v_{yi} and v_{xi} respectively.

[2 marks]

(ii) Write expressions for the vertical and horizontal displacements at any time t, for y and x respectively.

[2 marks]

(iii) Hence, show that the path traced out by the stone is parabolic.

[4 marks]

Total 15 marks

2. (a) Identify ONE similarity and ONE difference between transverse and longitudinal waves. Give an example of EACH type of wave.

____

____

____

____

[4 marks]

(b) A rifle was fired in a valley. The echo was heard 8.3 seconds later. If the temperature in the valley is 10 °C, determine the distance between the shooter and the reflecting valley wall.

(Assume that the speed of sound = 340 m s^{-1} at 0 °C and that for every 1 °C rise in temperature, the velocity of sound increases by 0.61 m s^{-1}.)

[3 marks]

(c) Two students conduct an experiment to measure the speed of sound. The first student stands *d* metres away from a wall in a large empty school hall and claps his hands so that his claps coincide with the echoes from the wall. The second student measures the time for 20 claps [that is, the time from the first hand clap to the last echo after the twentieth hand clap]. The procedure is repeated for several values of *d* and the results are recorded in Table 2.

TABLE 2

***d* metres**	**t_{20} seconds**	**$t = \frac{t_{20}}{20}$ seconds**	**$\frac{t}{2}$ seconds**
60	7.2		
70	8.2		
80	9.4		
90	10.6		
100	11.8		

GO ON TO THE NEXT PAGE

(i) Complete Table 2 on page 8 by inserting the missing values. **[2 marks]**

(ii) On the grid provided on page 9, plot a graph of *d* against *t*/2. Draw the best straight line through the points. **[4 marks]**

(iii) Use your graph to determine the speed of sound, *s*.

[2 marks]

Total 15 marks

3. (a) Show that both sides of the relation $PV = \frac{1}{3} N m\overline{c^2}$ have the same fundamental units.

[2 marks]

(b) Using the equation in (a) above, show that the mean kinetic energy of the molecules in 1 mole of an ideal monatomic gas is equal to (3/2) kT, where k is the Boltzmann constant.

[3 marks]

(c) Given that the root-mean-square (rms) speed of the molecules in a gas is inversely proportional to the square root of its molar mass, show that the ratio of the rms speeds of nitrogen to oxygen molecules in air is 1.07.

[Assume that the relative molar masses of nitrogen and oxygen are 28 and 32 respectively].

[2 marks]

(d) 1.12 moles of gas in a closed container at a temperature of 273 K exert a pressure of 1.01×10^5 Nm^{-2} on the walls of the container. Air is then extracted from the container so that the temperature is reduced to 223 K and the pressure reduced to 1.33×10^4 N m^{-2}. Determine the number of moles in the container under these new conditions.

[3 marks]

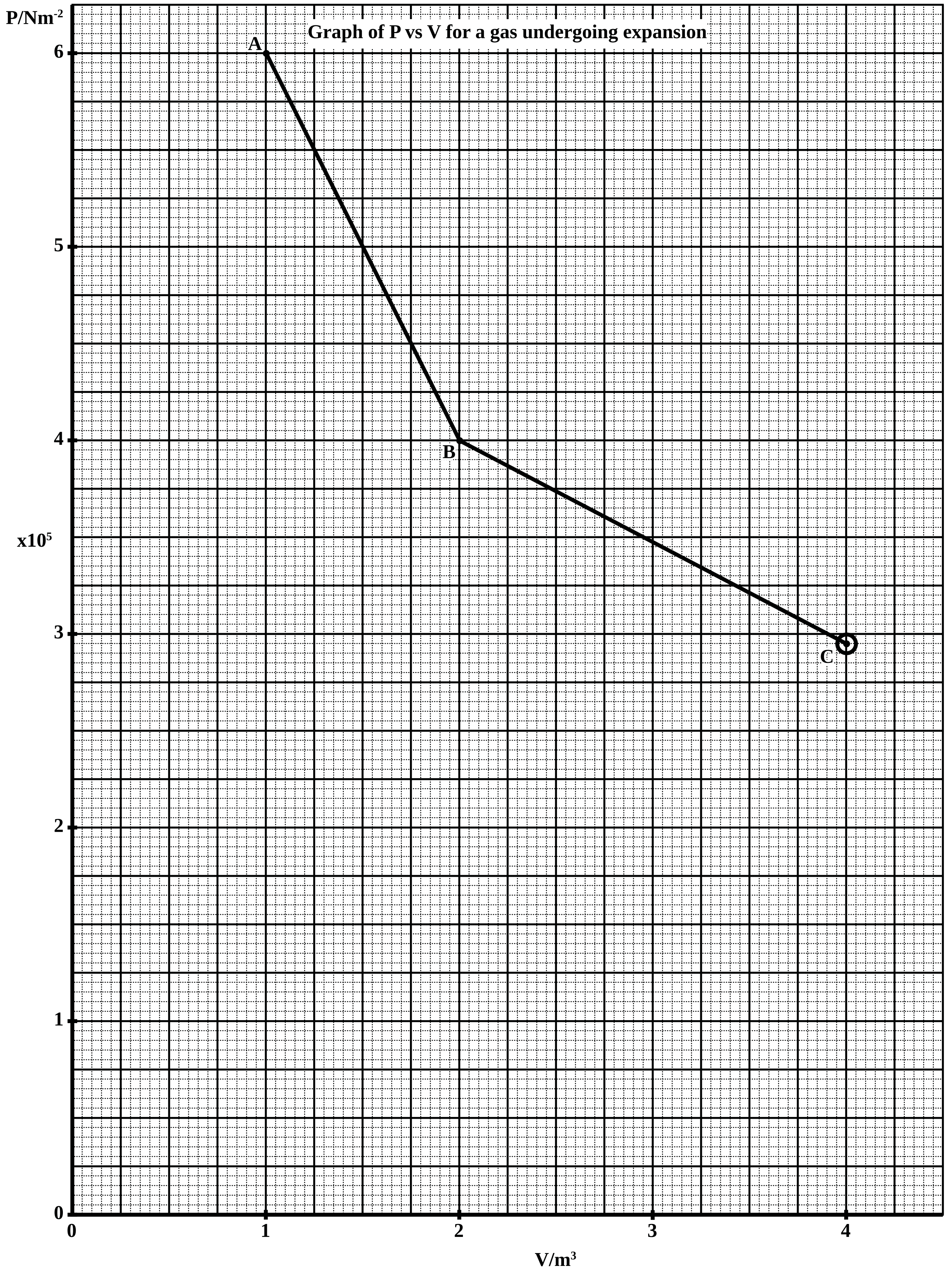
(e) A gas expands along the path of ABC as shown on page 13. Use the graph to determine the work done in this expansion.

[3 marks]

(f) If the expansion along AB had continued with no change in direction, what would be the volume of the gas at a pressure of 2×10^5 N m^{-2}?

[2 marks]

Total 15 marks


Graph of P vs V for a gas undergoing expansion
P/Nm-2
x10^5
6
5
4
3
2
1
0
A
B
C
0
1
2
3
4
V/m3

SECTION B

Answer ALL questions.

Write your answers in the spaces provided at the end of each question.

4. (a) State fully what is meant by the expression 'the Principle of Moments'. With the aid of an appropriate diagram, use the Principle of Moments to explain how it is possible for a person of mass 50 kg to lift someone twice as heavy on a see-saw. **[5 marks]**

(b) (i) State the law of conservation of momentum.

Two objects, of masses m_1 and m_2 respectively, travelling in opposite directions collide. The respective velocities of the objects before the collision (u_1 and u_2) and after (υ_1 and υ_2) are given in the Table 3 below.

TABLE 3

Velocity before Collision	Velocity after Collision
$u_1 = +4 \text{ m s}^{-1}$	$\upsilon_1 = -1.5 \text{ m s}^{-1}$
$u_2 = -3 \text{ m s}^{-1}$	$\upsilon_2 = +5.5 \text{ m s}^{-1}$

(ii) Assuming that the Law of Conservation of Momentum applies for this collision:

a) Calculate the ratio of the masses of the two objects, $m_1{:}m_2$.

b) Calculate the total kinetic energy of the two objects before the collision, given that $m_1 = 8.5$ kg.

c) Was this an elastic collision? Explain why or why not. **[10 marks]**

Total 15 marks

Write the answer to Question 4 here.

Write the answer to Question 4 here.

Write the answer to Question 4 here.

5. Figure 2 shows a stationary wave on a wire under tension. The frequency of the oscillations is 1200 Hz.

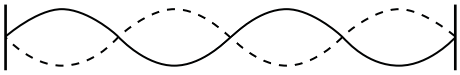


Figure 2

(a) If the length of the wire, L, is 0.4 m, calculate the speed of the waves moving along it. **[3 marks]**

(b) What will happen to the speed of the waves moving along the wire if

(i) the tension is doubled (all other factors remaining the same)?

(ii) the length is doubled (all other factors remaining the same)? **[2 marks]**

(c) The general equation for a travelling wave is $y = A_0 \sin\left(\frac{2\pi}{\lambda} x + 2\pi ft\right)$ where A_0 is the amplitude, λ is the wavelength and f is the frequency of the wave.

A sound wave is represented by the following equation:

$$y = 5 \times 10^{-4} \sin(740x + 251300t),$$

where x and y are measured in metres and t is measured in seconds.

Determine the following properties of the wave:

(i) Amplitude

(ii) Wavelength

(iii) Frequency

(iv) Speed **[7 marks]**

(d) Briefly describe a practical application in which this type of sound wave may be used. **[3 marks]**

Total 15 marks

Write the answer to Question 5 here.

Write the answer to Question 5 here.

Write the answer to Question 5 here.

6. (a) With the aid of a diagram, derive the expression $P = h \rho g$ at a depth, h, in a liquid of density, ρ. **[5 marks]**

(b) An aluminum cube, each side measuring 1 m, at sea level, lies on the sea floor at a depth of 2.5 km.

Determine the

(i) pressure exerted on the cube at this depth

[Assume that the density of sea water is constant and equal to 1.04×10^3 kgm^{-3}]

(ii) decrease in length (in mm) of any side of the cube resulting from this pressure, given that the Young's Modulus for aluminum is 69 GPa. **[5 marks]**

(c) The graph in Figure 3 shows the variation between force and extension for a thin piece of wire.

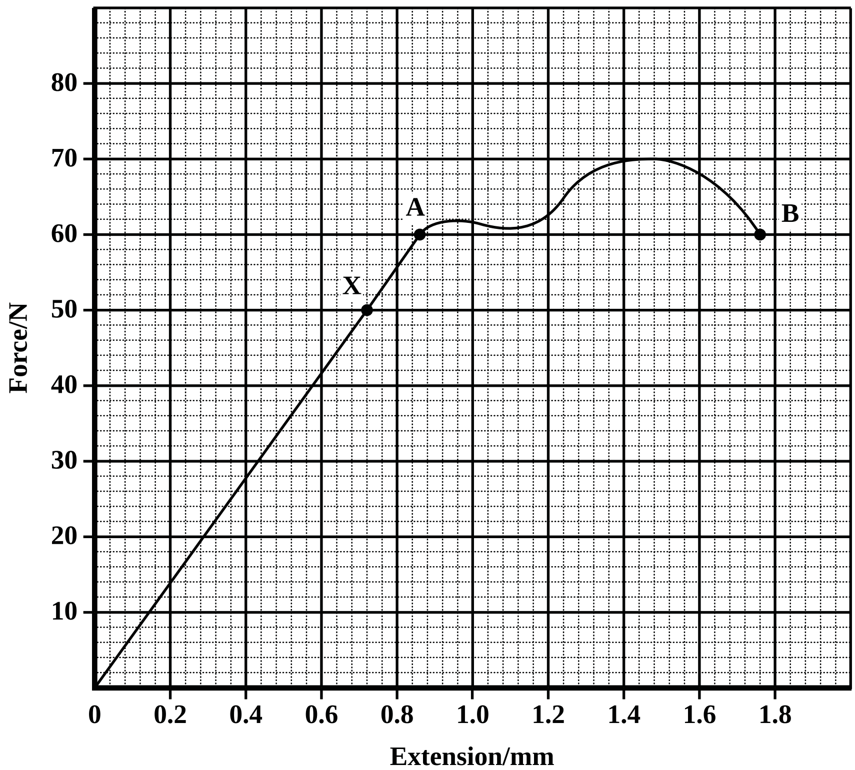


Figure 3

(i) Explain what happens to the wire at points A and B.

(ii) Using the graph, determine the strain energy in the wire at point X. **[5 marks]**

Total 15 marks

GO ON TO THE NEXT PAGE

Write the answer to Question 6 here.

Write the answer to Question 6 here.

Write the answer to Question 6 here.

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

TEST CODE **02138032**

MAY/JUNE 2013

FORM TP 2013240

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 1 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. ALL working MUST be shown.
4. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
5. You are advised to take some time to read through the paper and plan your answers.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

1. Given a wire specimen of unknown physical characteristics, design an experiment to determine its Young's Modulus.

List of apparatus:

____

____

____

____

____

____

[5 marks]

Diagram of setup:

[2 marks]

Procedure (including precautions taken):

[6 marks]

Manipulation of the results:

[1 mark]

Calculation of the Young's Modulus of the wire:

[2 marks]

Total 16 marks

GO ON TO THE NEXT PAGE

2. (a) You are required to conduct an experiment to investigate the refraction of light at an air/perspex boundary and hence to determine the critical angle for light travelling from perspex to air. Use the apparatus provided to set up the arrangement shown in Figure 1. P_1, P_2, P_3 and P_4 are optical pins. **[2 marks]**

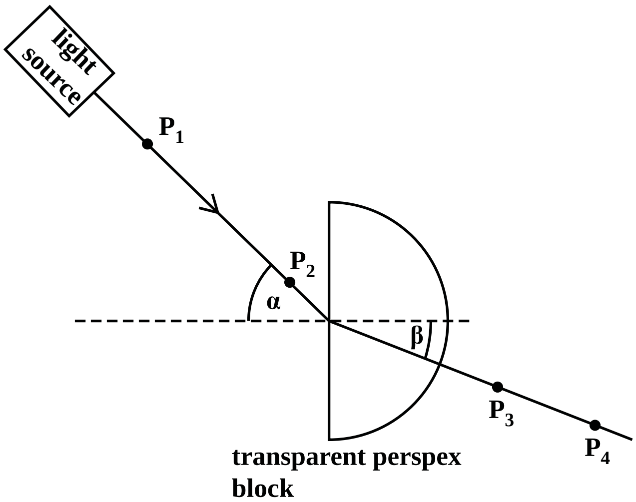


Figure 1

(b) (i) Use pins to trace the path of a beam of light through a semi-circular block of perspex.

(ii) Remove the perspex block and use the protractor to measure α and β and tabulate these values. Include in your table, columns for sin α and sin β.

(iii) Replace the perspex block and repeat steps (i) and (ii) for **four** different values of α.

(iv) Complete the columns for sin α and sin β. **[5 marks]**

(c) On the graph paper provided on page 5, plot a graph of sin α versus sin β and draw the best fit line. **[5 marks]**

(d) Extrapolate the line to determine the critical angle for light travelling from perspex to air. **[3 marks]**

(e) State ONE precaution you took in conducting this experiment.

____

____

[1 mark]

Total 16 marks

GO ON TO THE NEXT PAGE

3. A student interested in determining the specific heat capacity of an unknown liquid performs an experiment using the set-up shown in Figure 2 and obtains the data presented in Table 1.

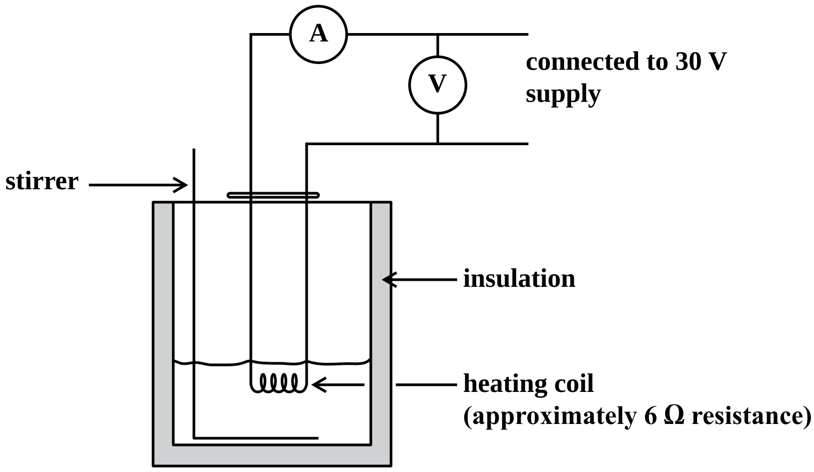


Figure 2

The following information relates to the diagram:

Initial temperature, $T_i = 30\ °C$
Mass of liquid = 0.5 kg
Voltage of supply = 30 V
Current in circuit = 5A

(a) Complete Table 1.

TABLE 1

Time, *t*/ s	**Temperature, T/ °C**	**$\Delta T = T - T_i$**
50	36	
100	42	
150	47	
200	53	
250	59	
300	64	

[1 mark]

(b) On the graph paper provided on page 8, plot a graph of $\Delta \mathbf{T}$ against t and draw the best-fit line. **[6 marks]**

(c) Calculate the gradient of the graph.

[2 marks]

(d) Using the gradient, determine the specific heat capacity of the liquid.

[3 marks]

(e) State TWO likely sources of errors and suggest methods for reducing them.

[4 marks]

Total 16 marks

GO ON TO THE NEXT PAGE

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

TEST CODE **02238020**

FORM TP 2013242

MAY/JUNE 2013

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in TWO sections. Answer ALL questions.
2. For Section A, write your answers in the spaces provided in this booklet.
3. For Section B, write your answers in the spaces provided at the end of each question in this booklet.
4. All working MUST be shown.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

NOTHING HAS BEEN OMITTED.

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$\dfrac{1}{4\pi\,\varepsilon_0} = 9.0 \times 10^{9}$ m F^{-1}
Elementary charge	e	=	1.60×10^{-19} C
Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
(Energy equivalence:	lu	=	931 MeV/c^{2})
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Answer ALL questions.

Write your answers in the spaces provided in this booklet.

1. (a) With the aid of a diagram, derive the formula for the equivalent resistance of two resistors in parallel.

[6 marks]

(b) Figure 1A is a potential divider circuit which splits up the 32 V from the battery into voltages, V_1 and V_2. Figure 1B is the equivalent circuit to Figure 1A.

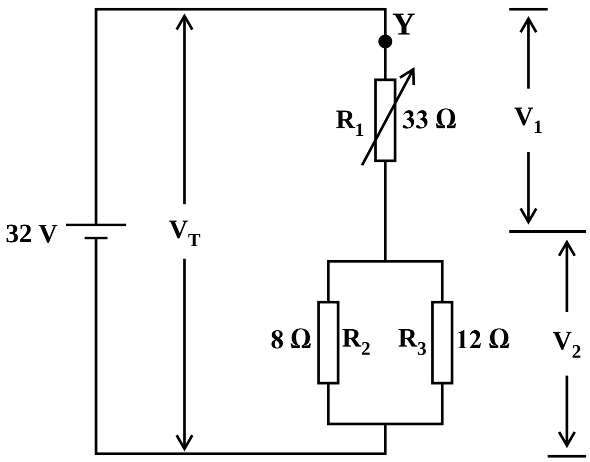


Figure 1A

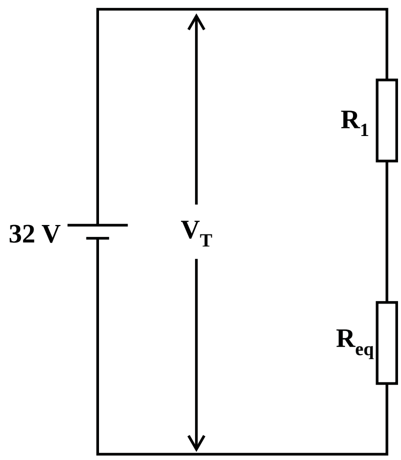


Figure 1B

GO ON TO THE NEXT PAGE

(i) Calculate the equivalent resistance, R_{eq} in Figure 1B.

[2 marks]

(ii) Determine the voltage, V_2.

[1 mark]

(c) The calculations above assume that the output resistance of the 32 V battery is zero. In practice this may not be so. In order to determine the internal resistance of the battery, an ammeter is inserted in the circuit at Y and the resistance of R_1 is reduced.

The terminal voltage, V_T, of the battery is monitored using a high resistance digital voltmeter. The readings of the ammeter (I) and the voltmeter (V_T) are recorded and tabulated. These are shown in Table 1 below.

TABLE 1

V_T/V	I/A
30	0.8
28	1.6
26	2.5
24	3.3
22	4.1

(i) Use the results above to plot a graph of I against V_T on the grid provided on page 7. **[3 marks]**

(ii) The slope, S, of the graph is related to the internal resistance, r, by $S = -\frac{1}{r}\ \Omega^{-1}$. Find S and hence determine the internal resistance, r, of the battery.

[3 marks]

Total 15 marks

2. Figure 2 shows the gain-frequency curve (the gain-frequency response) of a general purpose operational amplifier (op-amp).

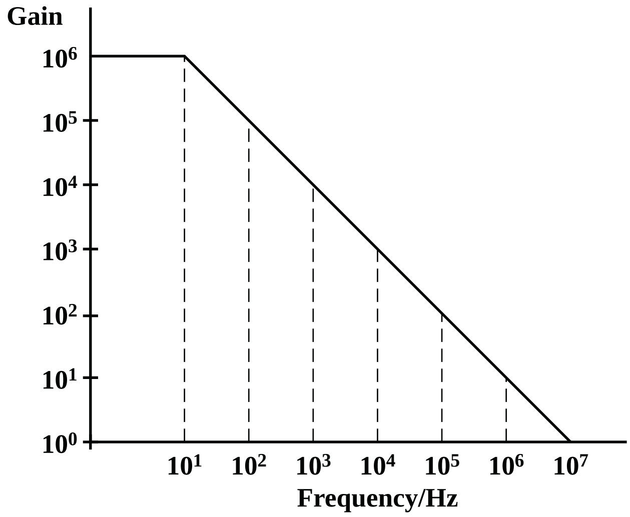


Figure 2

(a) Use the graph to determine the

(i) open loop d.c. gain of the amplifier

____

[1 mark]

(ii) unity gain bandwidth of the amplifier

____

[1 mark]

(iii) open loop bandwidth of the amplifier.

____

[1 mark]

(b) The op-amp with frequency response shown in Figure 2 is to be used as a non-inverting amplifier with the feedback resistance R_f = 330 k Ω and input resistance R_i = 3.3 k Ω.

(i) Draw the circuit diagram for this amplifier and label the resistors with their values.

[3 marks]

(ii) Calculate the gain of the amplifier.

[2 marks]

(iii) Use the open loop gain-frequency curve in Figure 2 to determine the closed loop bandwidth of this amplifier.

[2 marks]

(iv) Deduce the gain of the amplifier when the input resistance is made infinitely large (so that it can be effectively removed from the circuit).

[2 marks]

(v) What would be the input impedance of the resulting circuit?

[1 mark]

(vi) Identify the practical application for the circuit and state why it is suited for this application.

[2 marks]

Total 15 marks

3. (a) Describe the phenomenon of ‘photoelectric emission’.

[3 marks]

(b) Identify the property of a light source that would make it suitable for a demonstration of this phenomenon and give a reason why this property makes it suitable.

[2 marks]

(c) Calculate the energy (in eV) of a light photon of wavelength 200 nm.

[3 marks]

(d) The light source in Part (c) is used in a photoemission experiment with a metal whose work function is, $\Phi = 4.6$ eV. Calculate the maximum velocity of the electrons ejected from the surface.

[3 marks]

(e) The data in Table 2 were obtained for a photoemission experiment using Caesium.

TABLE 2

Stopping Potential V_s/V	**Wavelength** λ/nm
2.8	253
2.3	280
1.9	313
1.3	365
1.0	405

(i) On the grid provided on page 13, plot a graph of V_s against λ. **Ensure that the λ scale extends to 550 nm.** **[3 marks]**

(ii) From the graph determine the cut-off wavelength for Caesium.

[1 mark]

Total 15 marks

SECTION B

Answer ALL questions.

Write your answers in the spaces provided at the end of each question.

4. (a) Figure 3 shows a model of an electron gun similar to that found in older television sets and oscilloscopes. Electrons from a thermionic emitter are accelerated to high velocities by the potential difference between the plates and pass through a small hole in the negative plate.

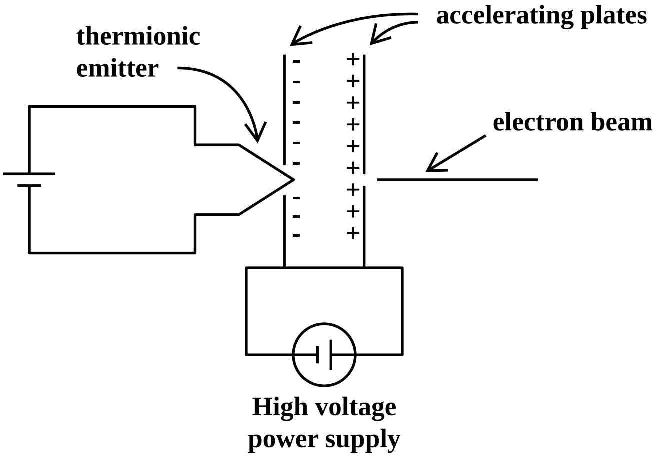


Figure 3

(i) By equating the gain in kinetic energy of the electrons to the work done in accelerating them, show that the velocity, v_e, of the emerging beam electrons is given by:

$$v_e = \sqrt{\frac{2e\ V_p}{m_e}}$$

where V_p is the potential difference between the plates.

(ii) Calculate the velocity of the electrons in the emerging electron beam when V_p = 25 kV. **[4 marks]**

(b) Figure 4 shows a long solenoid which has 1000 turns per metre and carries a current of 10 A.

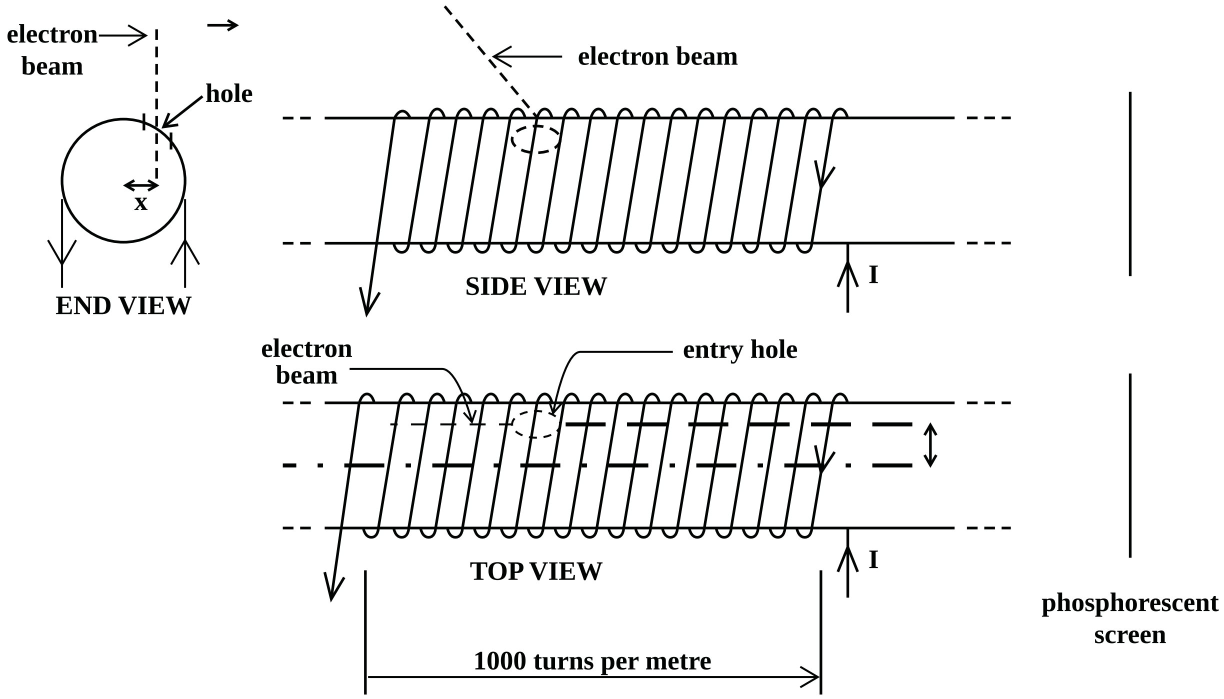


Figure 4

(i) Calculate the magnitude and direction of the magnetic field inside the solenoid.

[3 marks]

(ii) The solenoid is placed with its long axis horizontal so that a tiny hole (shown exaggerated in the diagram) faces upward and is displaced from the axis by a radial distance X. An electron beam is directed through the hole as shown in Figure 4.

a) Explain the effect on the electron's **horizontal** velocity component, resulting from its interaction with the B-field.

b) Describe the effect on the electron's **vertical** velocity component.

c) Describe the resultant motion of the electrons and the nature of the image produced on the phosphorescent screen when the B-field is large enough to prevent the electrons from touching the interior of the solenoid.

[8 marks]

Total 15 marks

Write the answer to Question 4 here.

Write the answer to Question 4 here.

Write the answer to Question 4 here.

Write the answer to Question 4 here.

5. Some modern cars incorporate an electronic system for turning on the headlights automatically whenever the light levels of the surroundings fall below a certain threshold. Other specifications of this type of system are:

- the lights can only come ON if the ignition switch S1 (logic A) is ON
- the headlights AUTO switch S2 (logic B) must be ON for the lights to come ON
- lighting level (logic C) below threshold is to be taken as logic 0

(a) Use logic Y to represent the output of this system and draw up the truth table for the operation of the headlight automatic switching circuit. **[8 marks]**

(b) The circuit shown in Figure 5 is proposed for implementing the headlight auto switching system.

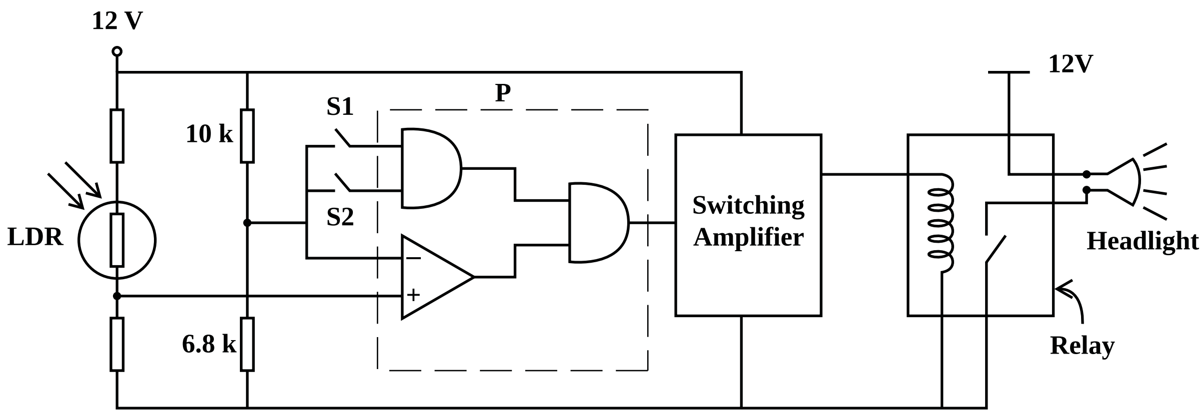


Figure 5

(i) Justify the need for the light dependent resistor (LDR) in the circuit.

(ii) Describe how a relay functions, stating why this device is necessary in the circuit. **[7 marks]**

Total 15 marks

Write the answer to Question 5 here.

Write the answer to Question 5 here.

Write the answer to Question 5 here.

6. (a) A radioactive sample initially contains N_0 radioactive particles. Its decay constant is λ and it decays to N particles in time, t. Write the equation describing this decay.

[1 mark]

(b) A capacitor, C, initially charged to voltage, V_0, will discharge through a resistance, R, according to the equation $V = V_0 \exp(-t/\tau)$, where τ is called the time constant.

(i) Write the equation expressing τ, in terms of R and C.

(ii) If the capacitive discharge is used to model radioactive decay, where voltage is the analogue of number of particles, what would be the relationship between time constant, τ and decay constant, λ?

(iii) Given that $t_{1/2}$ is the half-life of a radioactive sample, use the decay equation from Part (a) to show that $t_{1/2} = \frac{0.69}{\lambda}$.

[5 marks]

(c) The circuit shown below is used to model the decay of the radioactive isotope Francium-221, which has a half-life of 288 s. S_1 is initially switched to terminal *a*.

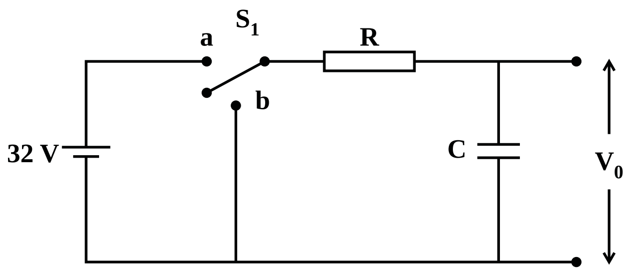


Figure 6

(i) Describe the change in the voltages across R and C, both of which initially had no voltage across them.

(ii) After a sufficiently long time, the voltages across R and C become fairly stable and S_1 is then switched to terminal b, so that the voltage across C models the decay of the Francium-221 isotope. Using a value of $R = 1\ \text{M}\Omega$, calculate the value of C needed to model the radioactive decay of Francium-221.

[6 marks]

(d) (i) State what is meant by the term ‘activity’ of a radioactive nucleus and write its expression in mathematical form.

(ii) A sample of Francium–221 contains 10^{12} atoms. Calculate its activity.

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

Write the answer to Question 6 here.

Write the answer to Question 6 here.

Write the answer to Question 6 here.

END OF TEST

TEST CODE **02238032**

FORM TP 2013243

MAY/JUNE 2013

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 2 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. ALL working MUST be shown.
4. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
5. You are advised to take some time to read through the paper and plan your answers.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

NOTHING HAS BEEN OMITTED.

1. In this experiment you will measure the resistance-temperature characteristic of a thermistor and determine β, its thermal exponent.

(a) Set up the apparatus as shown in Figure 1. Make sure that the switch, S, is open and the multimeter is set to ohms, before having the supervisor verify your setup.

[3 marks]

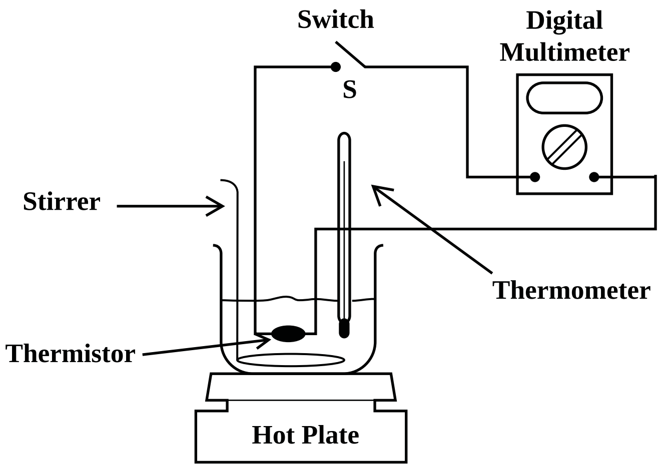


Figure 1

(b) Switch on the hot plate and wait for the water in the beaker to boil. Switch off the hot plate and immediately close the switch, S. Record the multimeter reading, R_T. Add ice water to the water in the beaker, stirring constantly, until the temperature falls close to 80 °C (80 °C $\pm$ 2 °C). Wait for the thermometer reading to stabilize. Record T_R and R_T. Repeat this procedure for the temperatures close to 60 °C, 40 °C and 20 °C. Complete Columns 1 and 2 in Table 1 to show your results.

TABLE 1

T_R (°C)	R_T (Ω)	T_R (K)	$\ln R_T$	$\frac{1}{T_R}$ (K^{-1})

[2 marks]

(c) Using the readings in Columns 1 and 2, complete Columns 3 and 4. **[2 marks]**

GO ON TO THE NEXT PAGE

(d) On the graph paper provided on page 5, plot a graph of $l\text{n } R_T$ versus $\frac{1}{T_R}$. **[4 marks]**

(e) The slope of this graph gives β, the thermal exponent of the thermistor. Determine β.

[2 marks]

(f) Use your graph to determine the resistance, R_T, of this thermistor when the temperature is 71 °C.

[3 marks]

Total 16 marks

2. Figure 2 shows a simplified representation of the apparatus used in Millikan's oil drop experiment.

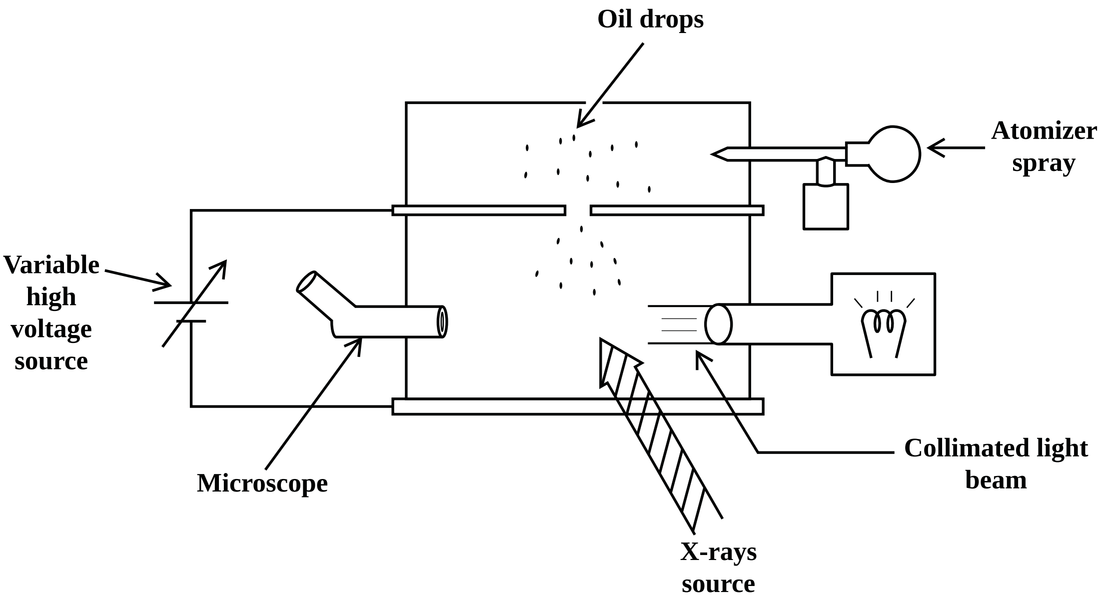


Figure 2

A rain of droplets falls through the hole and a particular droplet is selected for observation using a light beam and a microscope. The electric field is applied and adjusted so that the droplet remains stationary; its weight being balanced by the upward force exerted by the electric field. For such a stationary oil drop, its charge, q, is related to its radius, a, and stopping voltage, V, by:

$$q = \frac{a^3}{V}\ 115.8 \times 10^{-5} \text{ Coulombs}$$

Three sets of measurements from the oil droplet experiment are shown in Table 2.

TABLE 2

a (m × 10^{-6})	V (V)	$\frac{a^3}{V}$	q	n (to the nearest integer)	e
1.53	6710				
1.64	5480				
1.81	5570				

GO ON TO THE NEXT PAGE

(a) (i) Complete columns 3 and 4 of Table 2. **[2 marks]**

(ii) Given that EACH oil drop carries an integer number of electrons, use the values in column 4 to complete column 5 to show the number of electrons per droplet, n, (to the nearest integer). **[1 mark]**

(iii) Using the values in column 5, calculate the corresponding electronic charge, e, and complete column 6. **[1 mark]**

(b) In an actual experiment, it was observed that at the same time that one particular droplet is brought to rest, some droplets can be observed to be accelerating downward while other drops are accelerating upward.

(i) Explain why this happens.

____

____

____

____

[4 marks]

(ii) Explain why it is necessary to irradiate the chamber with X-rays.

____

____

____

____

[3 marks]

(iii) Explain why this experiment will only work for a limited range of voltages.

____

____

____

____

[2 marks]

(c) Figure 3 on page 9 shows the velocity-time graph for an oil drop moving between the electrodes of a Millikan apparatus.

(i) Use the graph to determine the terminal velocity of this oil drop.

____

[1 mark]

(ii) From the graph, determine the separation between the plates if the time for the drop to move between the plates is 27 seconds.

[2 marks]

Total 16 marks

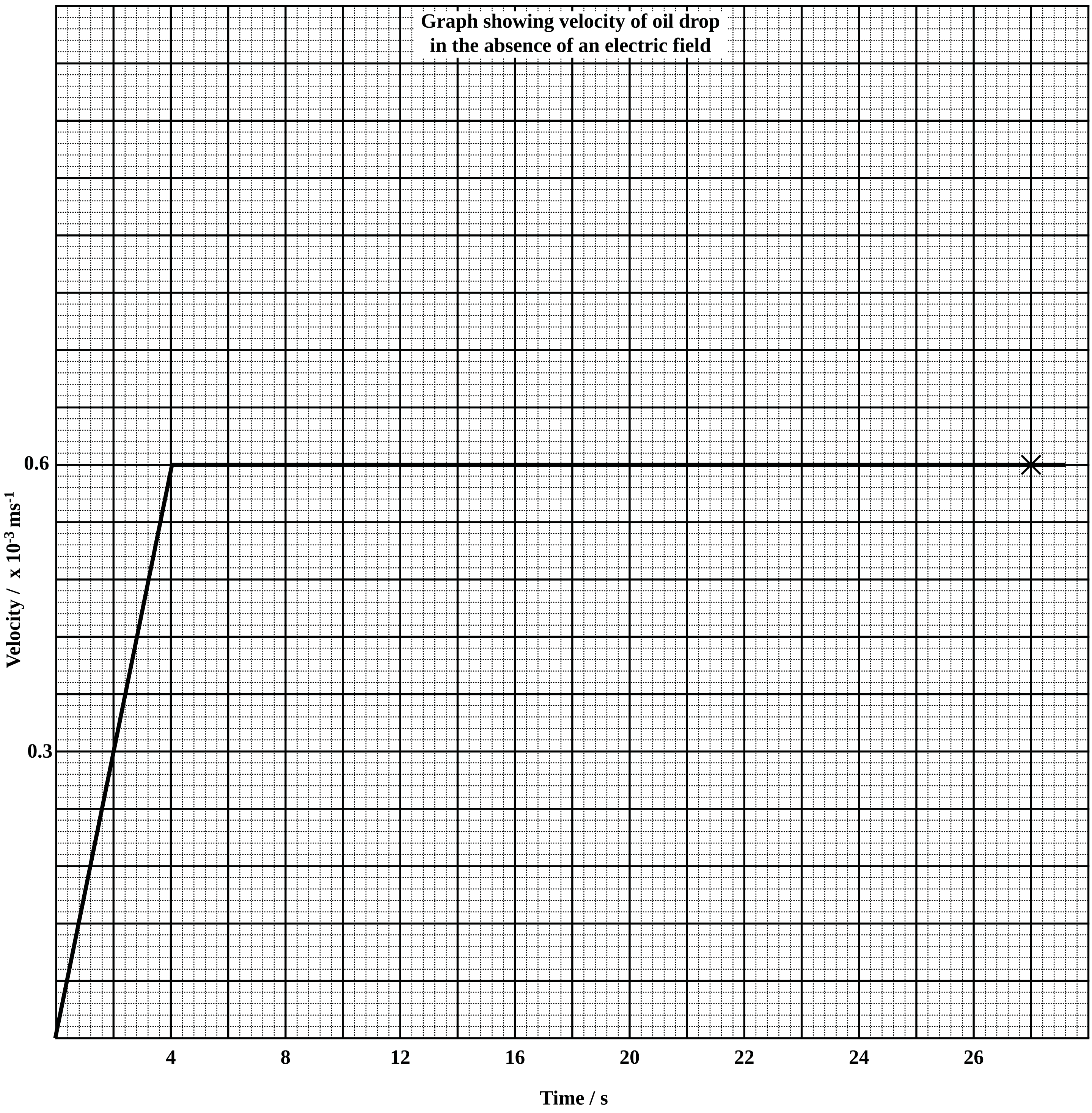

Graph showing velocity of oil drop
in the absence of an electric field
Velocity / x 10^{-3} ms^{-1}
0.6
0.3
4
8
12
16
20
22
24
26
Time / s

Figure 3

3. Design an experiment to plot the gain-frequency curve of an inverting amplifier circuit of gain 100.

List of apparatus:

[4 marks]

Circuit diagram:

[3 marks]

Outline of procedure:

[6 marks]

Tabulation of results:

[2 marks]

GO ON TO THE NEXT PAGE

Describe how you would treat the results recorded above.

[1 mark]

Total 16 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

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FORM TP 2014234

MAY/JUNE 2014

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 1 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in TWO sections. Answer ALL questions.
2. For Section A, write your answers in the spaces provided in this booklet.
3. For Section B, write your answers in the spaces provided at the end of each question in this booklet.
4. All working MUST be shown.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of digits in answers will be penalized.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

NOTHING HAS BEEN OMITTED.

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
Acceleration due to gravity	g	=	9.80 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^5 N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water	ρ_w	=	1.00×10^3 kg m^{-3}
Specific heat capacity of water	C_w	=	4200 J kg^{-1} K^{-1}
Specific latent heat of vaporization of water	l_v	=	2.26×10^6 J kg^{-1}
Avogadro's number	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan-Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in free space	c	=	3.00×10^8 m s^{-1}

SECTION A

Answer ALL questions.

Write your answers in the spaces provided in this booklet.

1. (a) Figure 1 shows a missile fired from the ground with a velocity of 300 m s^{-1} at an angle of inclination of 40°. The missile is in flight for 39 seconds.

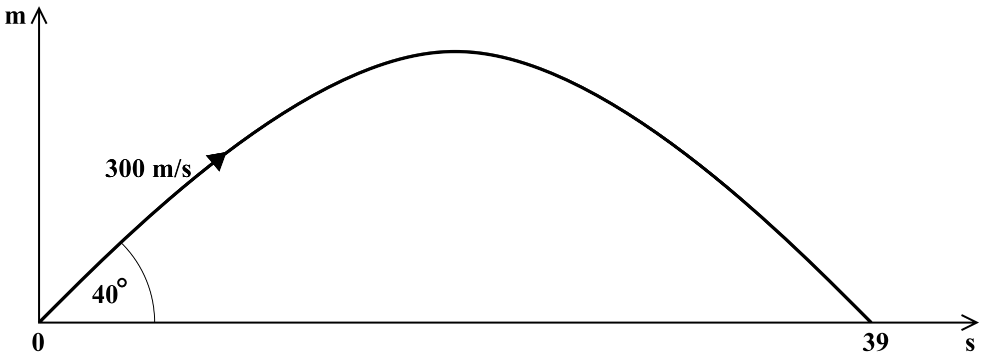


Figure 1

(i) Calculate the initial horizontal component of the missile's velocity.

[2 marks]

(ii) By neglecting air resistance, determine the horizontal range of the missile.

[2 marks]

(b) Figure 2, comprising six pictures labelled 1–6, represents a series of snapshots of a rubber ball in motion. The rubber ball was raised from the floor to a table of height 1.7 metres. It was then dropped from the table onto the floor and bounced up 1 metre.

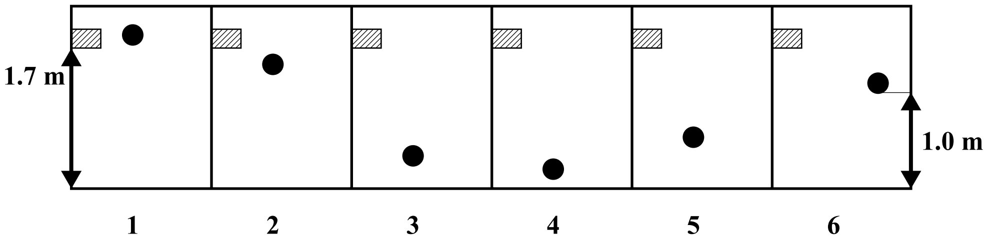


Figure 2

(i) In which picture does the ball have maximum potential energy?

____

[1 mark]

(ii) In which picture does the ball have maximum kinetic energy?

____

[1 mark]

(iii) How much potential energy has the ball lost from Picture 1 to Picture 6, if the ball weighs 2 N?

[2 marks]

GO ON TO THE NEXT PAGE

(c) Table 1 records the results of an experiment to determine the relationship between rebound height, $H_{rebound}$, and maximum height before rebound, H_{before}.

TABLE 1

H_{before} (m)	$H_{rebound}$ (m)
1.70	1.01
1.00	0.59
0.59	0.34
0.36	0.22
0.21	0.13

On the grid provided on page 7, plot a graph of $H_{rebound}$ versus H_{before} (starting at the origin). **[4 marks]**

(d) (i) Use the graph in (c) above to deduce the equation relating $H_{rebound}$ and H_{before} .

[2 marks]

(ii) How high would the ball be expected to rebound if it were dropped from a height of 2.04 m?

[1 mark]

Total 15 marks

2. (a) (i) What is the approximate range of frequencies which can be heard by a young adult with normal hearing?

[1 mark]

(ii) A fifteen-year-old girl frequently listens to her iPod via a single earphone placed in her right ear. Describe an experiment which you could do in the physics laboratory to test whether the frequency response of her right ear is now different from that of her left ear.

[3 marks]

(b) The speed of ocean waves in deep water is given by

$$v = \sqrt{\frac{g\lambda}{2\pi}} \ ,$$

where g is the acceleration of free fall and λ is the wavelength of the waves. Show that *T*, the period of the waves, in terms of g and λ is given by

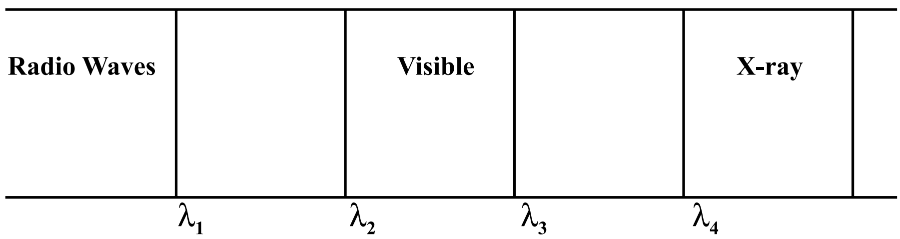
$$T = \sqrt{\frac{2\pi\lambda}{g}} \ .$$

[4 marks]

(c) Calculate the value of T when the wavelength is 0.8 m.

[2 marks]

(d) (i) Complete the diagram below to show the different regions of the electromagnetic spectrum.



Decreasing wavelength $\longrightarrow$

[2 marks]

(ii) Write down approximate values for the following:

$\boldsymbol{\lambda}_1$ ____________________

$\boldsymbol{\lambda}_2$ ____________________

$\boldsymbol{\lambda}_3$ ____________________

$\boldsymbol{\lambda}_4$ ____________________

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

3. In an experiment, a glass tube of cross sectional area 6 mm^2 is used to study the relationship between volume and temperature of a fixed mass of gas at constant pressure. Table 2 shows some of the results of the experiment.

TABLE 2

Temperature T (°C)	**Length of Gas Column (mm)**	**Volume V (mm^3)**
–35	83	
–3	89	
27	103	
57	110	
87	120	

(a) Complete Table 2 by inserting the missing values. **[2 marks]**

(b) (i) Using the data from the table, plot on the grid provided on page 11, a graph of volume against temperature. Use a scale which shows –325 °C to +100 °C on the temperature axis and begin at 0 mm^3 on the volume axis. **[4 marks]**

(ii) From your graph, determine the temperature at which the volume is zero.

[2 marks]

(c) If the gas is cooled enough, would its volume actually become zero? Suggest a reason for your answer.

____

____

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[2 marks]

(d) Determine temperature, in kelvin, at which the length of the gas column would be 70 mm.

[3 marks]

(e) (i) Write the equation of state for an ideal gas.

____

____

[1 mark]

(ii) Outline how this equation is applied in the experiment on page 10.

____

____

[1 mark]

Total 15 marks

NOTHING HAS BEEN OMITTED

SECTION B

Answer ALL questions.

Write your answers in the spaces provided at the end of each question.

4. (a) (i) Explain why a particle moving with constant speed along a circular path has an acceleration. **[2 marks]**

(ii) The value of radial acceleration is given by the expression v^2/r, where v is the speed and r is the radius of the path. Using base units, show that this expression is dimensionally correct. **[2 marks]**

(b) A racing car of mass 500 kg starts from rest and accelerates at 6.0 m s^{-2} along a straight horizontal road for a distance of 150 m. It then enters, at constant speed, a horizontal circular curve of radius 200 m.

What is the magnitude **and** direction of the resultant horizontal force acting on the racing car while it is travelling around the curve? **[4 marks]**

(c) A stone of mass 500 g is attached to a string of length 50 cm which will break if the tension exceeds 20 N. The stone is whirled in a vertical circle. The angular speed is slowly increased until the string breaks.

(i) Draw a diagram to show the forces acting on the stone in a vertical circle when it is at its

a) highest point **[1 mark]**

b) lowest point. **[1 mark]**

(ii) In what position along the vertical circular path is the string MOST likely to break? Suggest a reason for your answer. **[2 marks]**

(iii) At what angular speed will the spring break? **[3 marks]**

Total 15 marks

Write the answer to Question 4 here.

(a) (i)

(ii)

(b)

Write the answer to Question 4 here.

(c) (i) a) – b)

(ii) ______________________________

____

____

____

____

(iii)

GO ON TO THE NEXT PAGE

5. (a) In order for waves to produce an observable interference pattern, they must be coherent. Explain what is meant by the term ‘coherent’ when used in this context. **[1 mark]**

(b) A laser beam is incident on two narrow slits separated by a distance, a. The slits are at a distance, D, from a screen.

(i) With the aid of a diagram, show that the distance, y, between the centre of the interference fringe pattern and the first bright fringe is given by

$$y = \frac{\lambda D}{a}.$$ **[5 marks]**

(ii) With a pair of slits, spacing 0.20 mm, at a distance of 0.50 m from the screen, the bright fringes are 1.4 mm apart. What is the wavelength, in nm, of the light produced by the laser? **[2 marks]**

(c) A parallel beam of sodium light is incident normally on a diffraction grating. The angle between the two first order spectra on either side of the normal is 27.7° . Assuming that the wavelength of the light is 5.89×10^{-7}, find

(i) the number of rulings per mm on the grating **[4 marks]**

(ii) the number of spectra obtained on either side of the normal. **[3 marks]**

Total 15 marks

Write the answer to Question 5 here.

(a) ____

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Write the answer to Question 5 here.

(b) (i)

(ii)

(c) (i)

(ii)

6. (a) Figure 3 shows an example of a solar panel used in the Caribbean for heating domestic water. Discuss how the principles of conduction, convection, radiation and the greenhouse effect are applied in the design of this type of solar panels. **[7 marks]**

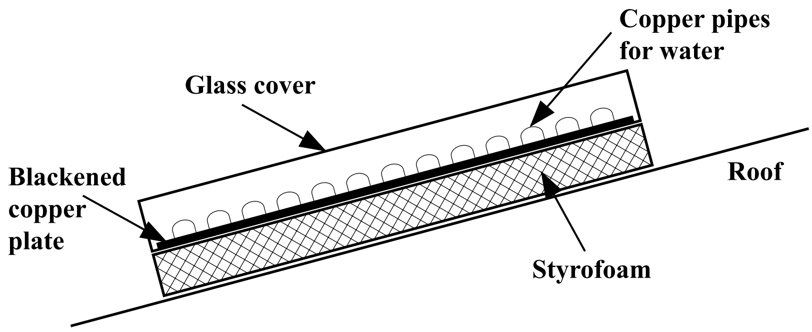

Figure 3

(b) The wall of a cold store is constructed from two layers of brick with a foam-filled cavity between as shown in Figure 4. Each of the layers of the brick walls is 10 cm thick and the foam cavity is 5 cm wide. On a typical warm day, the temperature outside is 30 °C while the temperature inside the cold room is kept at –5 °C.

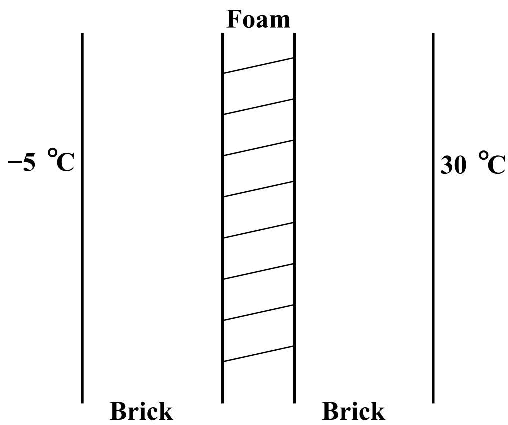

Figure 4. Cold store

(i) Sketch a graph to show how the temperature would vary across the wall. **[3 marks]**

(ii) The thermal conductivity of the brick is 0.48 W m^{-1} K^{-1} and that of the foam is 0.016 W m^{-1} K^{-1}. Calculate the thickness of brick which would have the same insulating effect as 5 cm of foam. **[2 marks]**

(iii) Determine the rate at which heat energy would pass through each square metre of this composite wall. **[3 marks]**

Total 15 marks

Write the answer to Question 6 here.

(a)

Write the answer to Question 6 here.

(b) (i)

(ii)

(iii)

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

TEST CODE **02138032**

FORM TP 2014235

MAY/JUNE 2014

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PHYSICS

UNIT 1 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

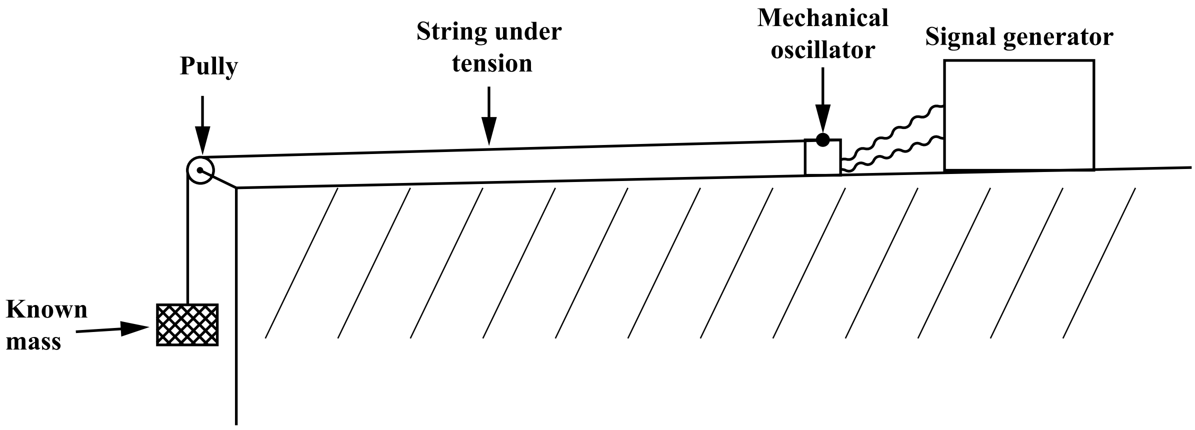
READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. ALL working MUST be shown.
4. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
5. You are advised to take some time to read through the paper and plan your answers.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

Answer ALL questions.

1. (a) Set up the apparatus as shown below.



(b) Perform the following steps:

(i) Turn on the signal generator.

(ii) Adjust the frequency setting to find the frequency required to produce a one-loop standing wave.

(iii) Record this frequency, *f*, and the corresponding wavelength, λ.

(iv) Repeat Steps (ii) and (iii) to find other frequencies which give 2, 3, 4 and 5 loops.

(v) Record these frequencies, *f*, and corresponding wavelengths, λ, in the table below.

Number of Loops	**Frequency f (Hz)**	**Wavelength λ (m)**	**$1/\lambda$ (m^{-1})**
1			
2			
3			
4			
5			

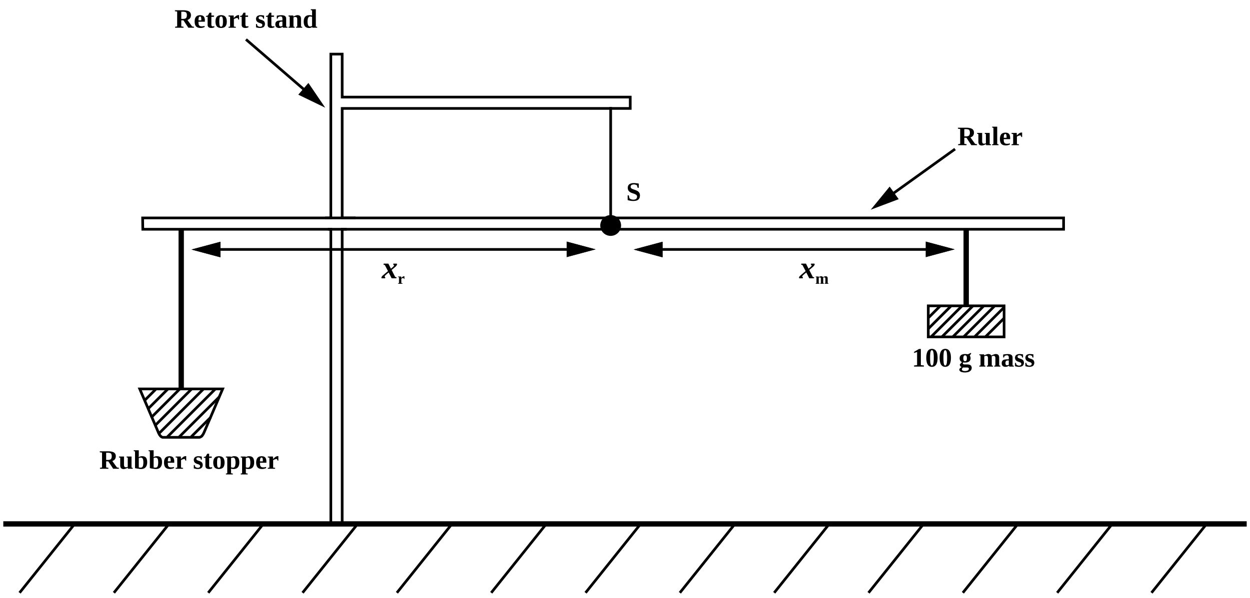
[7 marks]

(c) Use the grid on page 3 to plot a graph of *f* versus $1/\lambda$. From your graph determine the velocity of the waves on the string. **[9 marks]**

Total 16 marks

GO ON TO THE NEXT PAGE

2. In an experiment to determine the upthrust of an object, a student sets up the apparatus as shown below:



(a) Outline the procedure that the student should follow in conducting the experiment. Include any procedural precautions to be taken during the experiment.

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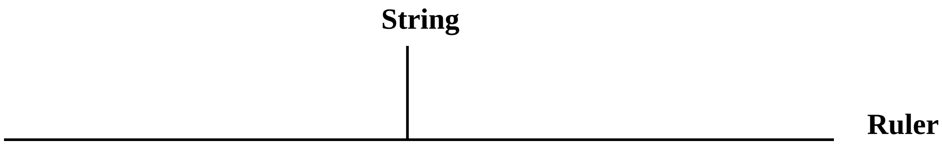
[7 marks]

(b) Indicate on the diagram below the forces acting on the ruler.



[3 marks]

(c) (i) State ONE precaution that the student must take before making measurements.

____

____

[1 mark]

(ii) Suggest why the precaution stated in 2 (c) (i) must be considered.

____

____

[1 mark]

(d) (i) What is meant by 'upthrust'?

____

____

[1 mark]

(ii) State the underlying principle on which the method of upthrust determination outlined in (a) on page 4 is based.

____

____

[1 mark]

(iii) Write an expression that the student can use to determine the upthrust of the object.

____

____

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[2 marks]

Total 16 marks

GO ON TO THE NEXT PAGE

3. Design an experiment to detemine the specific heat capacity of an unknown liquid by an electrical method. Use the following headings in your response.

(a) List of apparatus

____

____

____

____

____

[5 marks]

(b) Diagram of set-up

[2 marks]

(c) Procedure including precautions taken

[6 marks]

(d) Calculation of specific heat capacity

[3 marks]

Total 16 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

TEST CODE **02238020**

FORM TP 2014237

MAY/JUNE 2014

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

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PHYSICS

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in TWO sections. Answer ALL questions.
2. For Section A, write your answers in the spaces provided in this booklet.
3. For Section B, write your answers in the spaces provided at the end of each question in this booklet.
4. All working MUST be shown.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$\dfrac{1}{4\pi\,\varepsilon_0} = 9.0 \times 10^{9}$ m F^{-1}
Elementary charge	e	=	1.60×10^{-19} C
Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
(Energy equivalence)	lu	=	931 MeV/c^{2})
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Answer ALL questions.

Write your answers in the spaces provided in this booklet.

1. (a) (i) Define the term ‘capacitance’.

[1 mark]

(ii) State the unit in which capacitance is measured.

[1 mark]

(iii) Identify the two SI units that comprise the unit for capacitance stated in (a) (ii) above.

[1 mark]

GO ON TO THE NEXT PAGE

(b) Figure 1 shows a circuit including two capacitors in series, where $C_B = 60\ \mu F$.

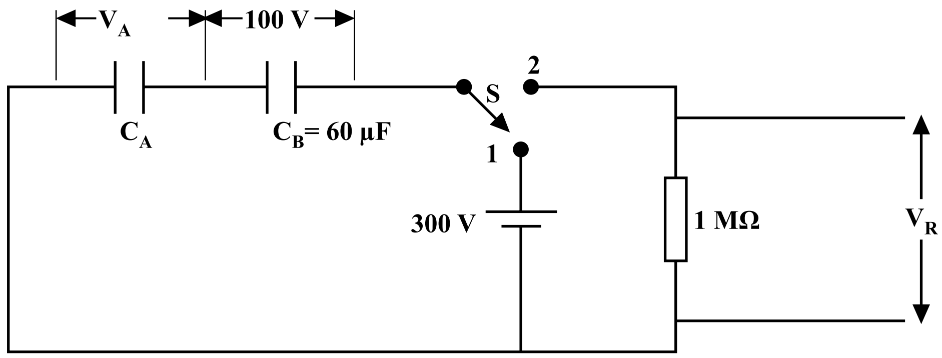

Figure 1

(i) Calculate the value of the voltage, V_A, when the switch, S, is in Position 1.

[2 marks]

(ii) Use your results from (b) (i) above to calculate the value of the capacitance, C_A.

[3 marks]

(iii) Show that the two capacitors in series in Figure 1 are equivalent to a single capacitor of value 20 μF.

[2 marks]

(c) The switch, S, is placed in Position 1 for several minutes and then changed to Position 2 and, V_R, the voltage across the resistor recorded every 20 seconds. The results obtained are presented in Table 1.

TABLE 1

Time ***t* (s)**	**Voltage × 10^2** **V_R (V)**
0	3.00
20	1.11
40	0.42
60	0.15
80	0.06

(i) On the grid provided on page 7, plot a graph of V_R against t for these results. **[3 marks]**

(ii) Draw the tangent to the curve at the point where $t = 0$. **[1 mark]**

(iii) Hence, determine the time constant of the voltage decay.

[1 mark]

Total 15 marks

NOTHING HAS BEEN OMITTED.

2. (a) On the grid provided below, draw a fully labelled sketch of the reverse bias I–V characteristic of a typical silicon p-n junction diode.

[3 marks]

(b) The forward bias characteristic I_D vs V_D of a junction diode may be modelled by the approximate Shockley equation

$$I_D = I_S \exp(V_D/V_T), \text{ where}$$

I_D = diode forward current

I_S = diode reverse saturation current

V_D = diode forward biased volt drop

V_T = thermal volt drop = 27 mV (at 30°C).

The results shown in Columns 1 and 2 of Table 2 were obtained in an experimental determination of the forward bias characteristic of a diode.

TABLE 2

V_D/V_T	I_D**(mA)**	**ln(**I_D**)**
10	0.55	
12	4.08	
13	11.1	
14	30.2	
16	223	

(i) Complete Column 3 of Table 2. **[3 marks]**

(ii) On the grid provided on page 11, draw a graph of ln(I_D) vs V_D/V_T. **[5 marks]**

(iii) Use your graph to calculate the reverse saturation current for this diode.

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[4 marks]

Total 15 marks

3. (a) Write a brief description of an experiment to determine the half-life of a radioactive sample.

[5 marks]

(b) State THREE properties of a radioisotope which would make it suitable for use in radiotherapy.

[3 marks]

(c) Carbon–14, ${}^{14}_{6}C$, has been used to date archaeological samples. It is produced naturally in the upper atmosphere by neutron bombardment of atmospheric nitrogen. Given that atmospheric nitrogen is ${}^{14}_{7}N$, derive the nuclear equation for the natural production of carbon–14.

[2 marks]

(d) Carbon–14 is unstable and decays to nitrogen by beta emission. This process has a half-life of 5730 years. Determine the percentage of carbon–14, relative to the initial amount, which would remain after 20 000 years.

(5 marks)

Total 15 marks

GO ON TO THE NEXT PAGE

SECTION B

Answer ALL questions.

Write your answers in the spaces provided at the end of each question.

4. (a) Define the term ‘electric field strength’ and state the unit in which it is measured. **[3 marks]**

(b) Two horizontal metal plates, in vacuo, are separated by 1 cm and a potential difference of 1 kV applied between them as shown in Figure 2.

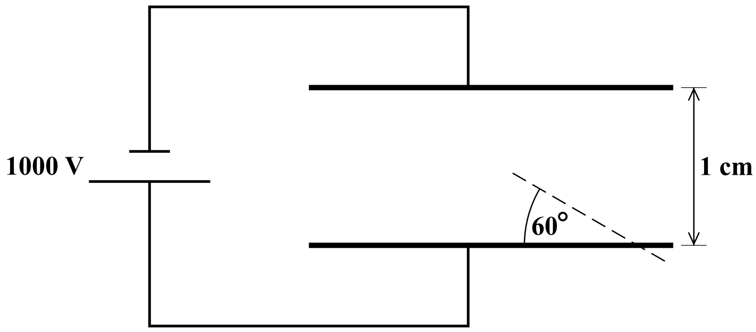

Figure 2

Calculate the electric field strength between the plates. **[2 marks]**

(c) A beam of electrons is projected through a hole in this positive plate with velocity, *v*, at an angle of 60° to the plate.

(i) Describe the subsequent motion of the electron beam. **[1 mark]**

(ii) Compare the motion of the electrons in the electric field with that of an object in the earth’s gravitational field by considering the effect of the fields on the horizontal and vertical velocity components. **[4 marks]**

(d) What must be the value of *v* if the beam is to just touch the negative plate? **[5 marks]**

Total 15 marks

Write the answer to Question 4 here.

(a)

(b)

(c) (i)

Write the answer to Question 4 here.

(ii)

(d)

5. (a) Draw truth tables and the circuit symbols for the 2-input NAND gate and the XNOR gate. **[4 marks]**

(b) The NAND gate and the NOR gate are sometimes referred to as universal gates because all other logic gates can be constructed from combinations of any one of them. Draw the NOR equivalents of the

(i) AND gate **[2 marks]**

(ii) OR gate **[1 mark]**

(iii) NAND gate. **[1 mark]**

(c) (i) Show, by using a truth table, that the circuit in Figure 3 produces the Exclusive NOR operation. **[3 marks]**

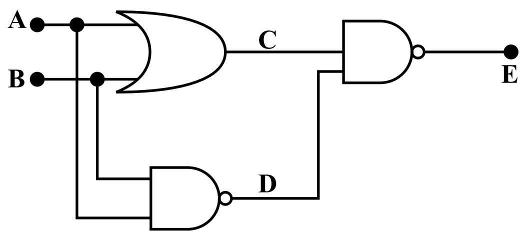

Figure 3

(ii) Hence, develop a circuit using NOR gates **only** which will provide Exclusive NOR operation. **[4 marks]**

Total 15 marks

Write the answer to Question 5 here.

(a)

Write the answer to Question 5 here.

(b) (i)

(ii)

(iii)

Write the answer to Question 5 here.

(c) (i)

(ii)

6. (a) With the aid of a CLEARLY LABELLED diagram, describe the way in which x-rays are usually produced for use in diagnostic medicine and dentistry. **[8 marks]**

(b) Express the energies of x-ray photons of wavelength 10^{-11} metres in electron Volts. **[3 marks]**

(c) The absorption coefficient of x-rays in a given material is dependent on the energies of the incident photons. Consider the case of a hypothetical material with an absorption coefficient of 0.3 cm^{-1} at the wavelength used in 6 (b).

What thickness of the material would be required to attenuate the intensity of a beam of x-rays to 1% of the incident intensity? **[4 marks]**

Total 15 marks

Write the answer to Question 6 here.

(a)

GO ON TO THE NEXT PAGE

Write the answer to Question 6 here.

(b)

(c)

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

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MAY/JUNE 2014

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CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 2 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. ALL working MUST be shown.
4. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
5. You are advised to take some time to read through the paper and plan your answers.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

Answer ALL questions.

1. A current-carrying conductor totally immersed in and at right angles to a constant magnetic field experiences a force proportional to its length and the current being carried. This experiment is to verify the relationship F = BIL newtons and use the data to find the average flux density between the poles of a magnet.

Materials provided:

(1) Approximately 24 cm of stout copper wire bent into a $\sqcup$-shaped frame, the base of the $\sqcup$ being approximately 6 cm

(2) A digital scale — 30 N max and accurate to 0.01N

(3) Flexible connecting wire of 3 A capacity

(4) 3 A DC ammeter

(5) Variable resistor (rheostat) — 3 A capacity

(6) DC power supply — 3 A capacity

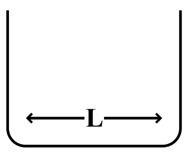
(7) Magnet

(8) Clamps, bosses, retort stand

(9) SPST switch — 3 A capacity

(10) 30-cm ruler

(a) Use the ruler to measure the length, L, of the horizontal portion of the $\sqcup$-shaped wire as shown below and record the measurement.



Length of horizontal portion

____

[1 mark]

GO ON TO THE NEXT PAGE

(b) Set up the apparatus as shown in Figure 1 ensuring that the wire frame is suspended so that it is free to move up and down between the poles of the magnet. The wire frame should not touch the poles of the magnet. The flexible wires connecting the power supply to the stiff wire frame should be firmly clamped several centimetres above their point of attachment to the wire frame.

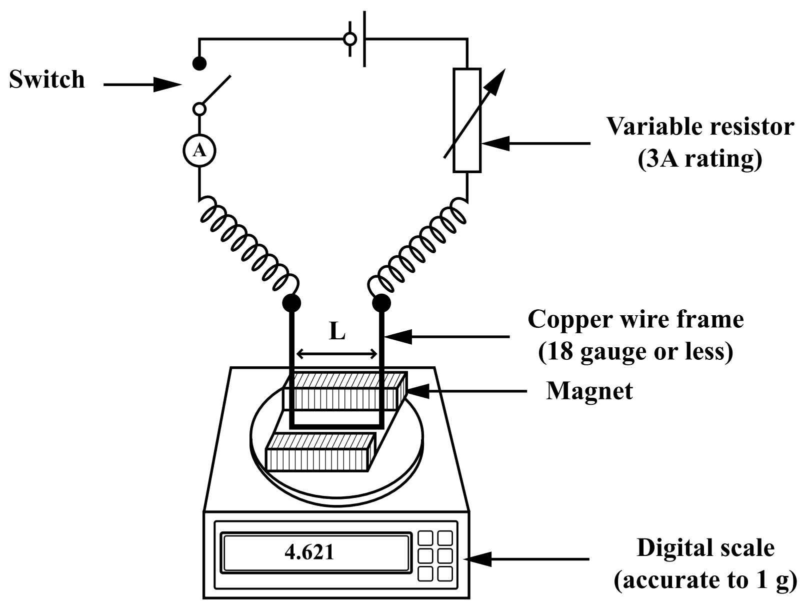


Figure 1

Make sure the stiff wire frame is perfectly still before switching on the current. Have the laboratory supervisor check your set-up before you switch on.

Record the initial reading, W, of the digital scale.

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[1 mark]

(c) Close the switch and adjust the current through the wire to approximately 0.4 amp. Record the current and the corresponding reading on the digital scale. Repeat for four other values of current, approximately 0.8 A, 1.2 A, 1.6 A and 2.0 A. Tabulate your results in Table 1.

TABLE 1

Current *I* (A)	**Force *F* (N)**	**$\vert F - W \vert$ (N)**
0.0	W	0

[4 marks]

(d) On the grid provided on page 5, plot a graph of $| F - W |$ against I and draw your **best** straight line through the points. **[5 marks]**

(e) Determine the slope of your graph and use it to find the mean flux density in the space between the poles of the magnet.

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[4 marks]

(f) Explain why the value of B obtained from this experiment is an average of the magnetic flux density between the poles of the magnet.

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[1 mark]

Total 16 marks

GO ON TO THE NEXT PAGE

NOTHING HAS BEEN OMITTED.

2. The objective of this experiment is to determine whether the volume of liquid left in an emptying burette follows an exponential decay curve, that is,

$$V = V_0 \exp(-\mu t)$$

where V_0 is the initial volume of liquid in the burette ($t = 0$)

V is the volume of liquid at any time, t

μ is the decay constant

and could therefore be used to model the decay of a radioactive element.

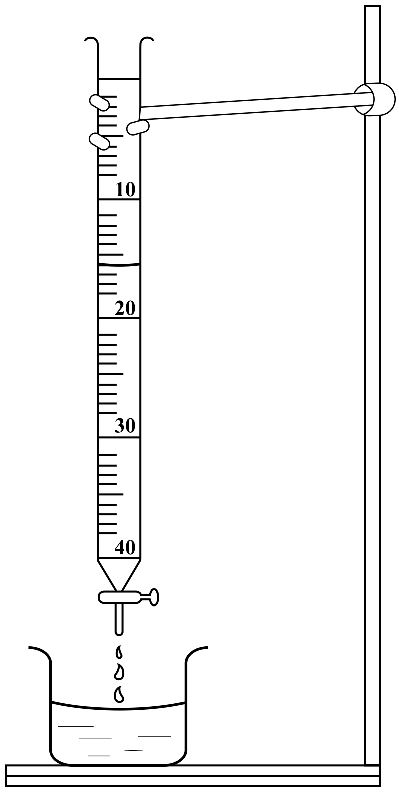

Figure 2

The apparatus is set up as shown in Figure 2. With the tap closed, a 50-ml burette is filled with coloured water above the 0 mark to start with a volume of 50 ml (V_0). The tap is then opened and as the liquid runs out the time taken for the volume of liquid to fall from 0 ml to 5 ml is recorded. The volume V remaining in the burette is also recorded.

More liquid is then added to the burette to bring the volume of liquid level back to 0 ml. The tap is opened once more and the time taken for the volume of liquid to fall from 0 ml to 10 ml is recorded.

The process is then repeated for successive decreasing 5-ml intervals until the volume falls to 5 ml. The readings obtained are presented in Table 2.

TABLE 2

V (ml)	t (secs)	V/V_0	$\ln(V/V_0)$
50	0		
45	4		
40	11		
35	20		
30	29		
25	41		
20	57		
15	77		
10	104		
5	137		

(a) Complete Table 2 by calculating and inserting the values for V/V_0 and ln (V/V_0). **[4 marks]**

(b) Use values from Table 2 to plot a graph, on the grid provided on page 9, of In(V/V_0) vs t and draw your **best** straight line through the points. **[7 marks]**

(c) Using evidence from the graph, justify whether liquid decay is exponential.

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[4 marks]

(d) State ONE precaution or adjustment to the apparatus which you would use to improve the accuracy of your results.

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[1 mark]

Total 16 marks

NOTHING HAS BEEN OMITTED.

3. After studying alternating current waveforms, half-wave rectification and capacitor smoothing, a student proposes the following hypothesis.

The peak-to-peak value of the ripple voltage obtained with a capacitor smoothed, half-rectified sinusoidal waveform is proportional to the logarithm (base 10) of the value of the smoothing capacitor used.

Design an experiment to test the validity of the hypothesis above. Use the following headings in your response.

(a) List of apparatus

[3 marks]

(b) Circuit diagram

[5 marks]

(c) Procedure

[4 marks]

(d) Table of results

[1 mark]

(e) Relevant graph (page 13) **[1 mark]**

(f) Analysis

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[1 mark]

(g) Conclusion:

Do your results support or invalidate the hypothesis presented above?

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[1 mark]

Total 16 marks

(e)

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

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PHYSICS

UNIT 1 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in TWO sections. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. All working MUST be shown.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
6. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
7. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	atm	=	1.00×10^5 N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water	ρ_w	=	1.00×10^3 kg m^{-3}
Specific heat capacity of water	C_w	=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice	L_f	=	3.34×10^5 J kg^{-1}
Specific latent heat of vaporization of water	L_v	=	2.26×10^6 J kg^{-1}
Avogadro's constant	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan-Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in free space	c	=	3.00×10^8 m s^{-1}
Planck's constant	h	=	6.626×10^{-34} J s
Triple point temperature	T_{tr}	=	273.16 K
1 tonne	t	=	1000 kg

SECTION A

Answer ALL questions.

Write your answers in the spaces provided.

1. (a) State, in words, Newton's law of universal gravitation.

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[2 marks]

(b) The planet Mars may be considered to be an isolated sphere of diameter 6.79×10^6 m with its mass of 6.42×10^{23} kg concentrated at its centre. A rock of mass 1.40 kg rests on the surface of Mars.

(Assume that the dimensions of the rock are negligible compared to the radius of Mars.)

(i) Determine the weight of the rock on Mars.

[3 marks]

(ii) Show that the gravitational potential energy of the rock is -1.77×10^7 J.

[2 marks]

GO ON TO THE NEXT PAGE

(c) (i) Table 1 presents data representing the variation of the weight (W) of a satellite with its radial distance (R) from the Earth's centre as it orbits the Earth. On the grid provided in Figure 1 **(page 5)**, plot a graph of weight (W) versus $1/R^2$ to reflect this variation. **[4 marks]**

TABLE 1: VARIATION OF WEIGHT OF SATELLITE WITH ITS RADIAL DISTANCE

$\frac{1}{R^2} \times 10^{-15}$ m^{-2}	Weight (W) $\times 10^5$ N
21	1.18
18	1.05
16	0.95
12	0.66
9	0.58
7	0.40
6	0.35
4	0.24

(ii) Find the gradient of the graph and hence determine the mass of the satellite. (Mass of Earth, $M_E = 5.6 \times 10^{24}$ kg)

[4 marks]

Total 15 marks

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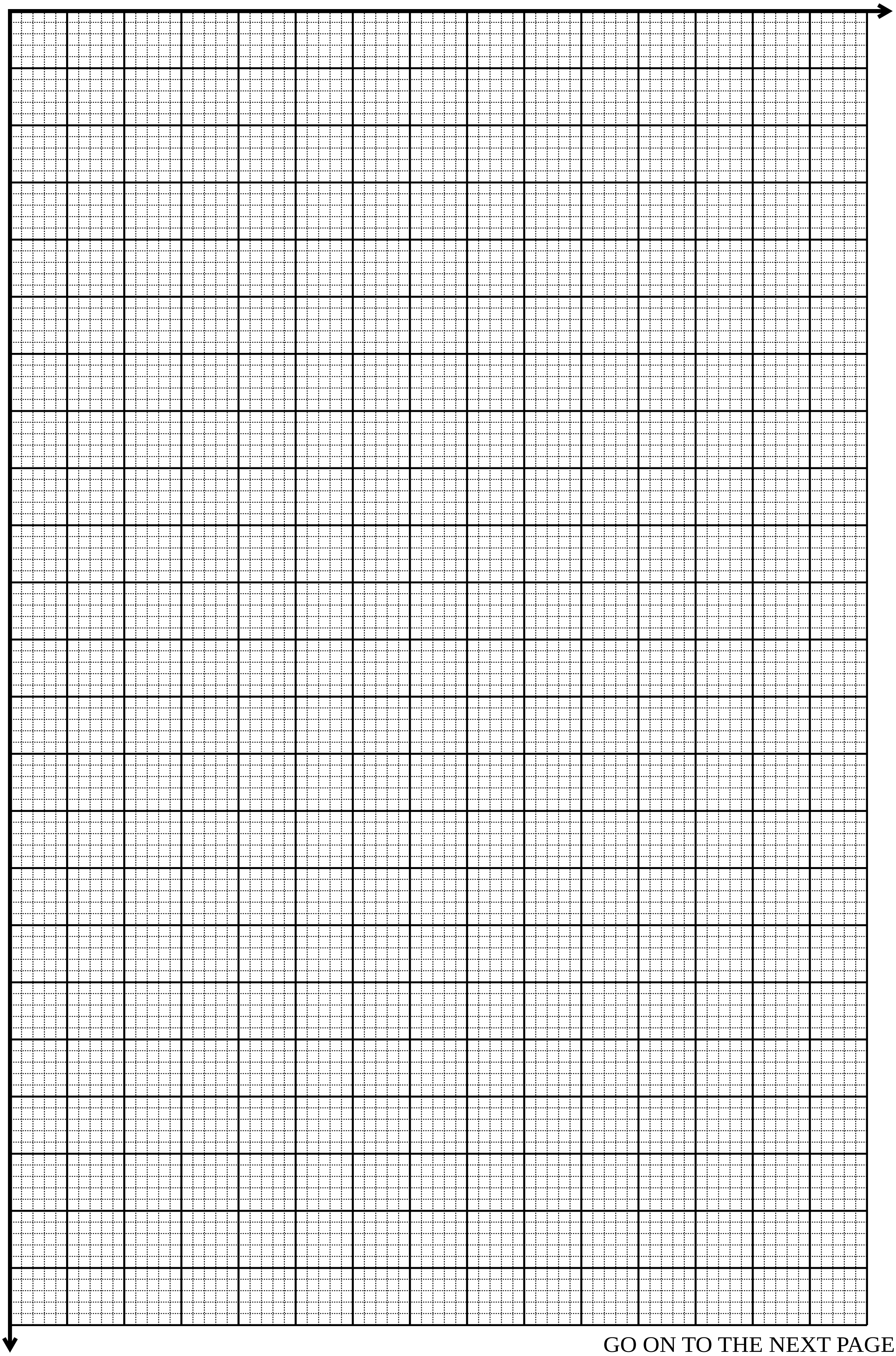

Figure 1. Variation of weight with radial distance

2. (a) (i) State TWO conditions that must be satisfied for simple harmonic motion to occur.

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[2 marks]

(ii) A horizontal plate is vibrating vertically, as shown in Figure 2.

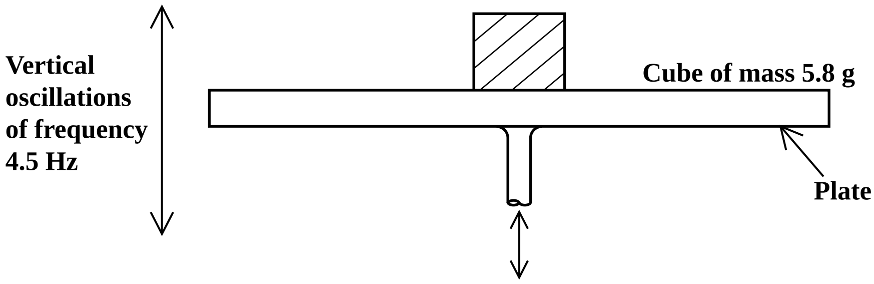

Figure 2. Horizontal plate

The plate undergoes simple harmonic motion with a frequency of 4.5 Hz and amplitude 3.0 mm. A metal cube of mass 5.8 g rests on the plate. Calculate the maximum kinetic energy of the cube.

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[3 marks]

(iii) The amplitude of oscillation of the plate in (a) (ii) is gradually increased. The frequency remains constant. At a particular amplitude and at the position of maximum displacement, the cube loses contact with the plate for an instant. Explain why the cube loses contact with the plate.

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[2 marks]

(iv) Calculate the amplitude of oscillation at the instant the cube loses contact with the plate.

[3 marks]

(b) Figure 3 shows a block which oscillates horizontally between two identical springs, each with spring constant, k. The vibrator has a constant amplitude.

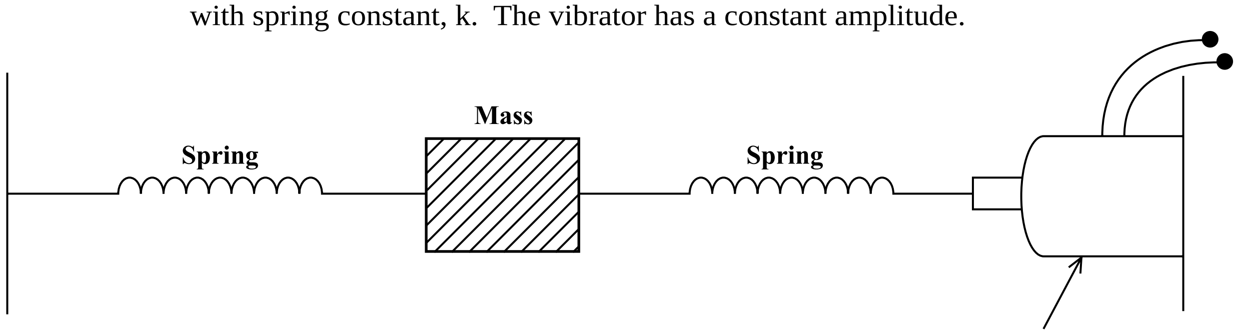

Figure 3. Oscillating block

As the frequency is changed, the amplitude of oscillation of the block is measured. Table 2 shows the data recorded.

TABLE 2: VARIATION OF AMPLITUDE WITH FREQUENCY

Frequency ***f*** **/Hz**	**Amplitude** ***y*****/cm**
2.8	1.2
5.5	1.8
8.3	3.0
11.0	4.2
12.7	4.4
13.8	4.3
16.5	1.4

(i) On the grid provided in Figure 4 **(page 9)**, plot a graph of amplitude of oscillation, *y*, against frequency, *f*. **[4 marks]**

(ii) Use your graph to determine the angular frequency for the block when it is oscillating at maximum amplitude.

Angular frequency

[1 mark]

Total 15 marks

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Figure 4. Amplitude of oscillation versus frequency

3. (a) A resistance thermometer and a thermocouple thermometer are both used at the same time to measure the temperature of a water bath. Explain why the thermometers may record different temperatures even though they are calibrated accurately and are at equilibrium.

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[2 marks]

(b) (i) What is meant by the term 'absolute zero of temperature' ?

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[1 mark]

(ii) State how the 'absolute thermodynamic scale of temperature' differs from other temperature scales.

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[1 mark]

(c) The temperature of a water bath increases from 50.00 °C to 80.00 °C. Determine, in kelvin, and to an appropriate number of significant figures,

(i) the temperature 50.00 °C

[1 mark]

(ii) the change in temperature of the water bath.

[1 mark]

(d) An empirical centigrade temperature can be determined and defined in terms of any suitable thermometric property. Select ONE type of thermometer with a suitable thermometric property and describe briefly the procedure and necessary readings to be taken in order to use this thermometer to determine a random temperature, θ.

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[5 marks]

(e) The relationship between the resistance, R, of a wire at temperature t/°C as measured by a mercury thermometer, and the resistance, R_0, at 0 °C is

$$R = \frac{R_0}{1 + \alpha t^2} \ ,$$

where $\alpha = 5.0 \times 10^{-5}$ °C^{-2}.

(i) Calculate, in terms of R_0, the resistance of the wire at 100 °C and at 80 °C as measured by the mercury thermometer.

[2 marks]

GO ON TO THE NEXT PAGE

(ii) If the resistance of the wire is used as a thermometric property, what is the temperature reading of the resistance thermometer when the reading on the mercury thermometer is 80 ^{o}C?

[2 marks]

Total 15 marks

SECTION B

Answer ALL questions.

Write your answers in the spaces provided.

4. (a) Figure 5 shows a resultant vector, A, at an angle θ to the horizontal.

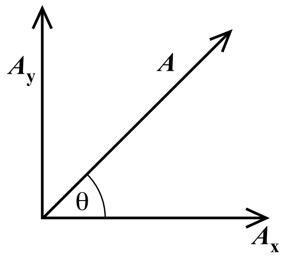

Figure 5. Resultant vector

Write expressions for A_x and A_y in terms of A and θ.

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[2 marks]

(b) A jogger runs 145 m in a direction 20.0° east of north and then 105 m in a direction 35.0° south of east.

(i) Represent his resultant displacement using a suitable vector diagram.

[3 marks]

GO ON TO THE NEXT PAGE

(ii) Determine his northerly displacement from his starting point.

[3 marks]

(iii) Hence, determine his resultant displacement from his starting point.

[4 marks]

(c) It is said that sprinters in a 100 m race accelerate for the first one-third of the race. The following formula, $t = \left(\frac{2s}{a}\right)^x$ is proposed to compute the duration of the acceleration phase. By comparing the units, find the value of x.

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

5. (a) Long-sightedness is an eye defect that affects many persons. Explain, using suitable optical sketches, how long-sightedness occurs and how it can be corrected.

[4 marks]

(b) Use a ray diagram to show how focused images are formed in a magnifying glass.

[3 marks]

(c) An object is placed 12 cm from a converging lens of focal length 18 cm.

Determine

(i) the position of the image and its distance from the lens

[4 marks]

(ii) whether the image is virtual or real

....

[1 mark]

(iii) the magnification of the image and hence its orientation.

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

6. (a) Define the term 'Young's modulus'. Include a suitable formula in your definition.

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[3 marks]

(b) Explain the differences between 'elastic deformation' and 'inelastic deformation' by making reference to Hooke's law and energy changes in materials.

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[4 marks]

(c) A bone has a Young's modulus of approximately 1.8×10^{10} Pa. Under compression, it can withstand a stress of about 1.5×10^{8} Pa before breaking. Assuming that the femur (thigh bone) is 0.47 m long, calculate the amount of compression that this bone can withstand before breaking. (**State your answer in mm**.)

\

[3 marks]

(d) Figure 6 shows a crane that is used for lifting heavy objects.

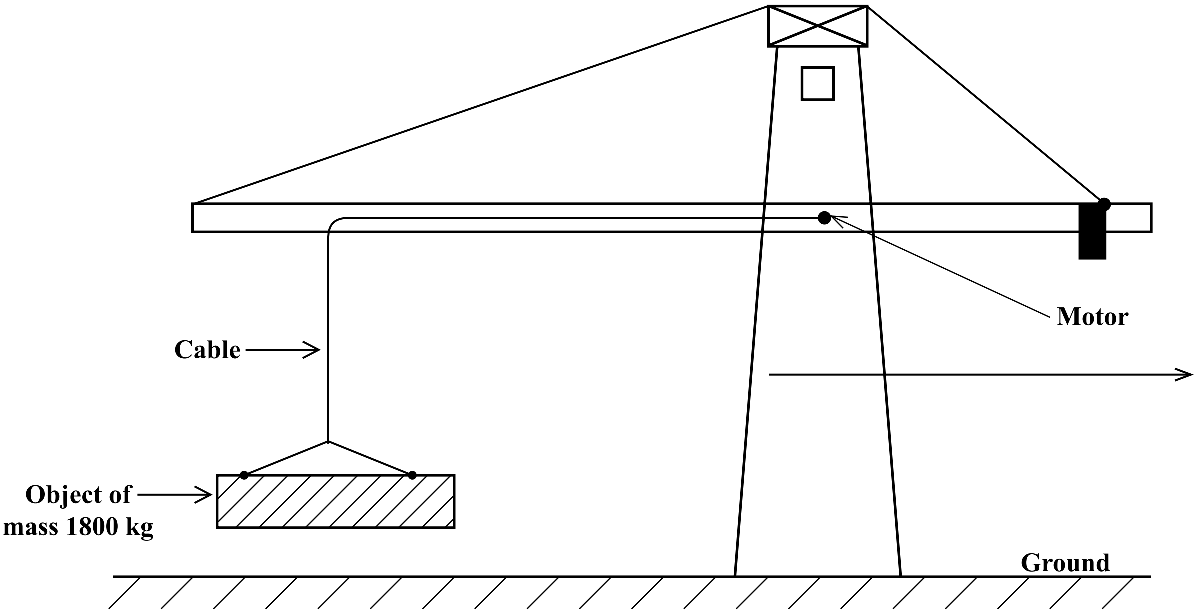

Figure 6. Crane

The motor in the crane lifts a total mass of 1800 kg from rest on the ground. The cable supporting the mass is made from steel of Young's modulus 2.4×10^{11} Pa. The cross-sectional area of the cable is 1.3×10^{-4} m^2. As the mass leaves the ground, the strain in the cable is 0.0010.

(Assume the weight of the cable is negligible.)

(i) Use the Young's modulus of the steel to determine the tension in the cable.

[2 marks]

(ii) Assuming it is an 8-tonne crane and that the length of the cable is 8 m, determine the extension in the cable when it is operating at maximum load.

[3 marks]

Total 15 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

TEST CODE **02138032**

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MAY/JUNE 2015

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CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 1 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. ALL working MUST be shown.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
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Answer ALL questions.

Write your answers in the spaces provided in this booklet.

1. This experiment involves verifying Hooke's law and determining the force constant of a spring.

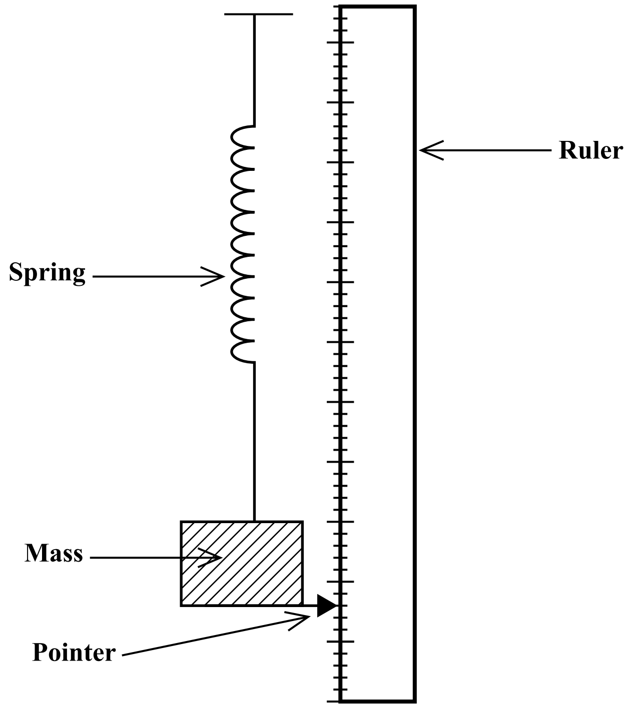

Figure 1. Determining the force constant of a spring

1. Set up the apparatus as shown in Figure 1 with the lightest of the slotted masses attached to the lower end.

2. Clamp the scale vertically alongside the spring so that the small pointer or flag attached to the spring moves close to the scale, but without touching it.

3. Record the reading of the pointer, P_0, and the mass attached to the spring.

4. Increase the load by successive increments of one slotted mass and record the pointer reading EACH time. When EIGHT such readings have been taken, start unloading the masses and again record the pointer readings in Table 1.

TABLE 1: READINGS

Load (kg)	**Weight W (N)**	**Pointer Readings (cm)**			
		Load Increasing P_i	**Load Decreasing P_d**	**Mean Reading P_m**	$P_m - P_o$

(a) State the value of P_o.

....

[1 mark]

(b) Complete Table 1 to reflect your data. **[5 marks]**

(c) On the grid provided in Figure 2 **(page 5)**, plot a graph of W versus $P_m - P_o$ and draw the best straight line through the points. **[7 marks]**

(d) Use the straight-line portion of the graph to determine the force constant of the spring.

[3 marks]

Total 16 marks

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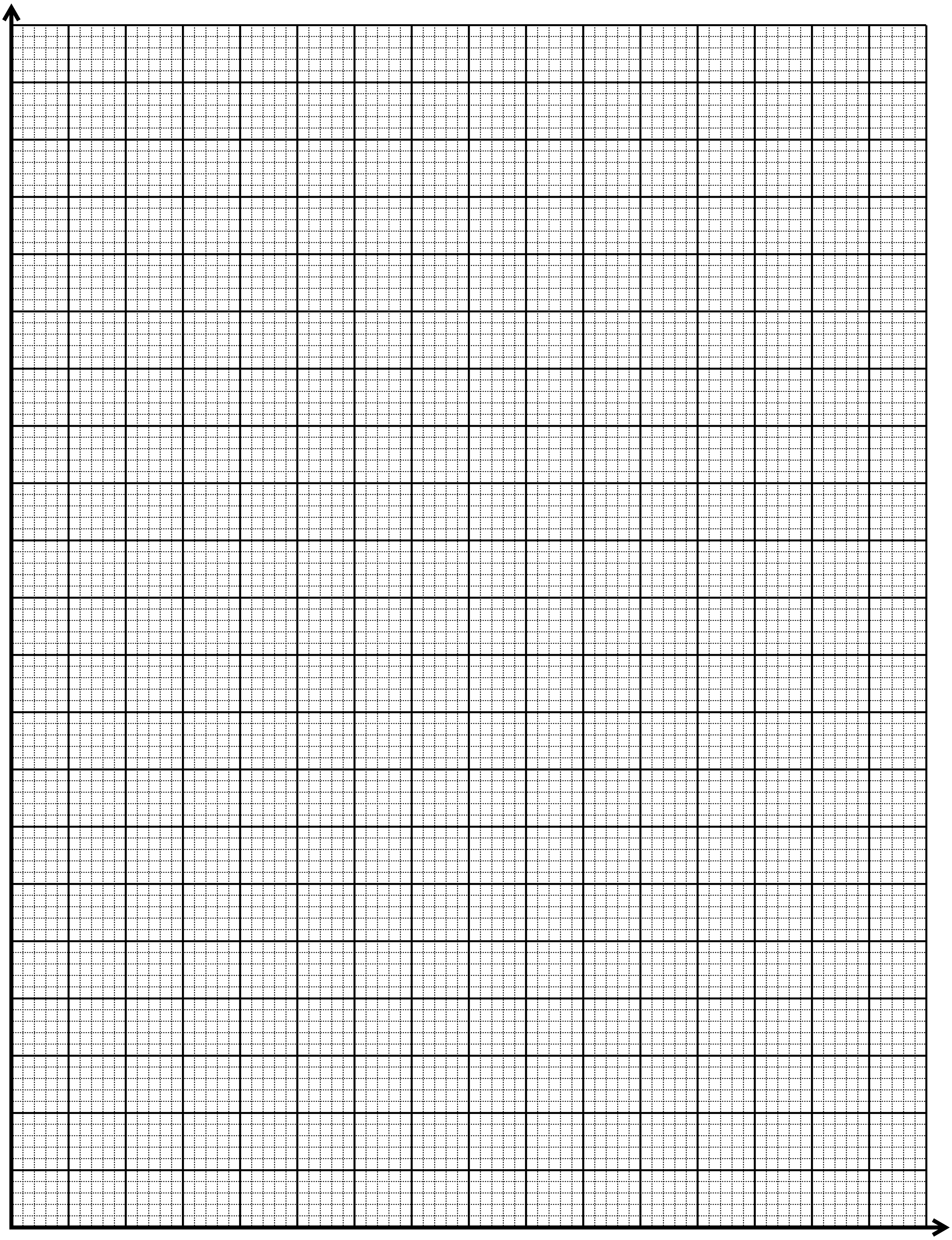

Figure 2. ***W*** **versus** $P_m - P_o$

2. A student interested in showing that a small sphere falls with a constant velocity through a viscous fluid, sets up the apparatus shown in Figure 3 and performs the following steps:

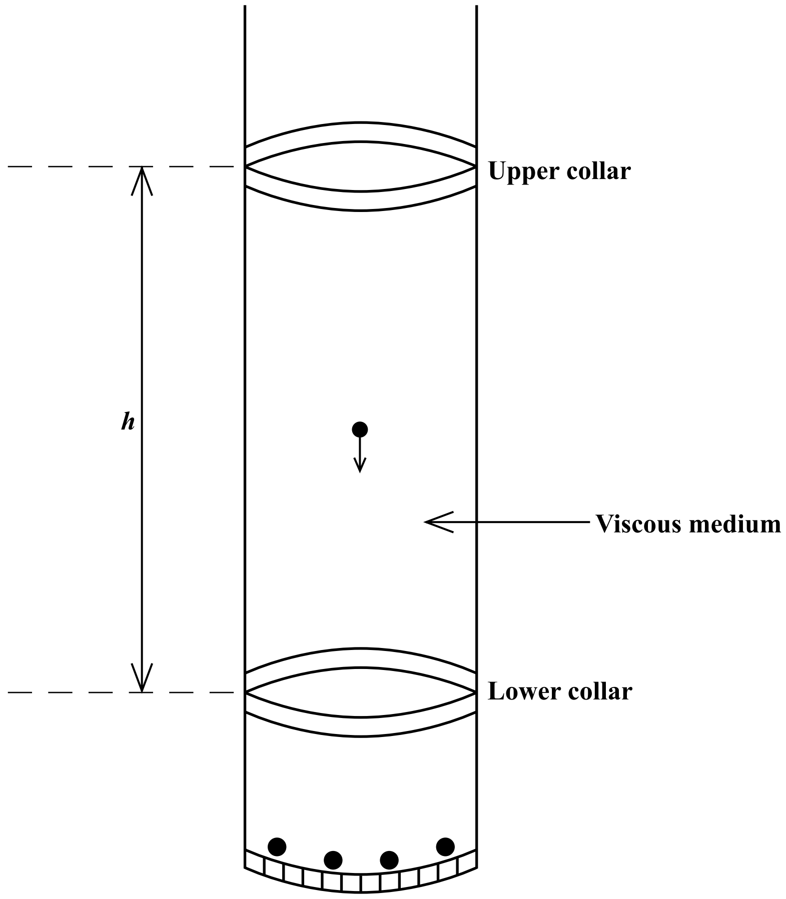

Figure 3. Small sphere in viscous medium

1. Adjusts the distance, h (cm), between the paper collars so that their upper edges are approximately 80 cm apart.

2. Carefully measures and records this distance, h (cm).

3. Drops a small sphere centrally down the jar and with the stopwatch finds the time, t_1, it takes to travel the distance, h, between the upper edges of the paper collars.

   Repeats this step using a second identical sphere to obtain a confirmatory reading, t_2.

   Uses t_1 and t_2 to determine an average value, t, for the time it takes for the sphere to travel between the upper edges of the paper collars.

4. Keeping the lower collar fixed, moves the upper collar down by 5 cm and repeats Step 3.

5. Repeats Step 4 and records distance, h, and time, t, as shown in Table 2.

TABLE 2: DISTANCE TRAVELLED BY SPHERE

Distance Between Collars ***h*/cm**	**Time of Fall**		
	t_1 /s	t_2 /s	t/s
80	22.0	21.0	
75	18.2	18.0	
70	17.0	17.0	
65	15.0	14.6	
60	13.7	13.3	
55	12.2	11.8	
50	10.2	10.1	
45	8.7	8.3	
40	6.6	6.9	

(a) Complete Table 2. **[1 mark]**

(b) On Figure 4 **(page 9)**, plot a graph of *h* against corresponding values of *t*, and determine from the graph the terminal velocity of the sphere.

[7 marks]

(c) List THREE precautionary measures that the student should take during this experiment.

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[3 marks]

(d) Given that each metal sphere has a mass of 30 g, determine the drag force when the sphere has reached terminal velocity.

[3 marks]

(e) Explain how the drag force varies from the time the sphere is released.

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[2 marks]
Total 16 marks

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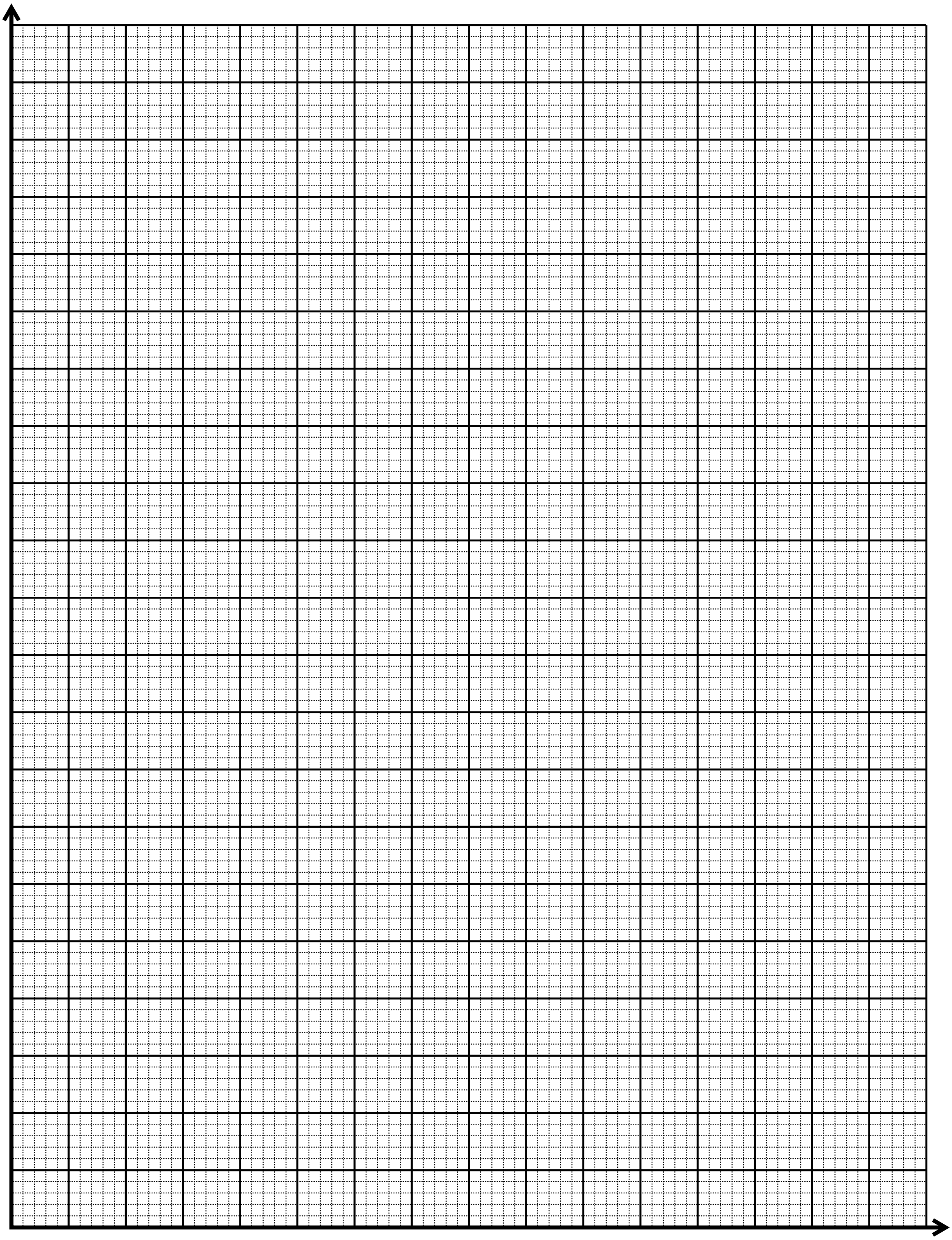

Figure 4. Distance (*h*) versus time (*t*)

3. Design an experiment to determine how the maximum audible frequency of hearing varies with distance using the following guidelines:

(a) List of apparatus

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[2 marks]

(b) Diagram of setup

[3 marks]

(c) Procedure (including precautions taken)

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[6 marks]

(d) Results and calculations

[2 marks]

(e) TWO errors that might influence the results obtained in this experiment

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[2 marks]

(f) Conclusion

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[1 mark]

Total 16 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

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FORM TP 2015262

MAY/JUNE 2015

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in TWO sections. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. All working MUST be shown.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
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DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

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LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
	$\dfrac{1}{4\pi\,\varepsilon_0}$	=	9.0×10^{9} m F^{-1}
Elementary charge	e	=	1.60×10^{-19} C
Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Energy equivalence	$1\,u$	=	931 MeV/c^{2}
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Answer ALL questions.

Write your answers in the spaces provided.

1. (a) Figure 1 shows a coil of wire made from an unknown metal.

Figure 1. Resistance coil

Distinguish between the 'electrical resistance' and the 'electrical resistivity' of the coil of wire.

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[2 marks]

(b) Identify the circuit shown in Figure 2.

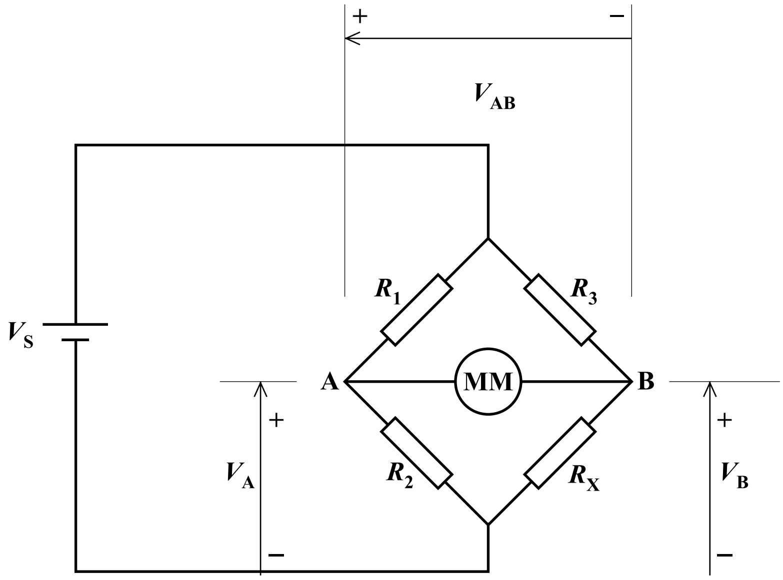

Figure 2. A circuit

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[1 mark]

(c) By treating the circuit in Figure 2 as two potential dividers in parallel, show that the voltage, V_{AB}, indicated by the multimeter (MM) will be given by:

$$V_{AB} = \left(\frac{R_2}{R_1 + R_2} - \frac{R_X}{R_X + R_3} \right) V_S$$

[4 marks]

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(d) The circuit in Figure 2 is set up with the following component values:

$R_1 = R_3 = 4.0\ \text{k}\Omega$ $R_2 = 1.0\ \text{k}\Omega$ $V_s = 20\ \text{V}$

R_x is one of several resistance coils made from pieces of wire drawn from an unknown metal of different lengths, *L*. The wires all have the same diameter of 0.6 mm. The values of V_{AB}, the voltage indicated by the multimeter (MM) and the length of wire, *L*, were recorded in Table 1.

TABLE 1: RESULTS

Length of Coil Wire ***L* (metres)**	**Multimeter Reading** **V_{AB} (volts)**
100	2.73
80	2.98
60	3.24
40	3.49
20	3.74
0	4.02

(i) On the grid provided in Figure 3 **(page 7)**, plot a graph of V_{AB} against *L* and draw your best straight line through the points. **[4 marks]**

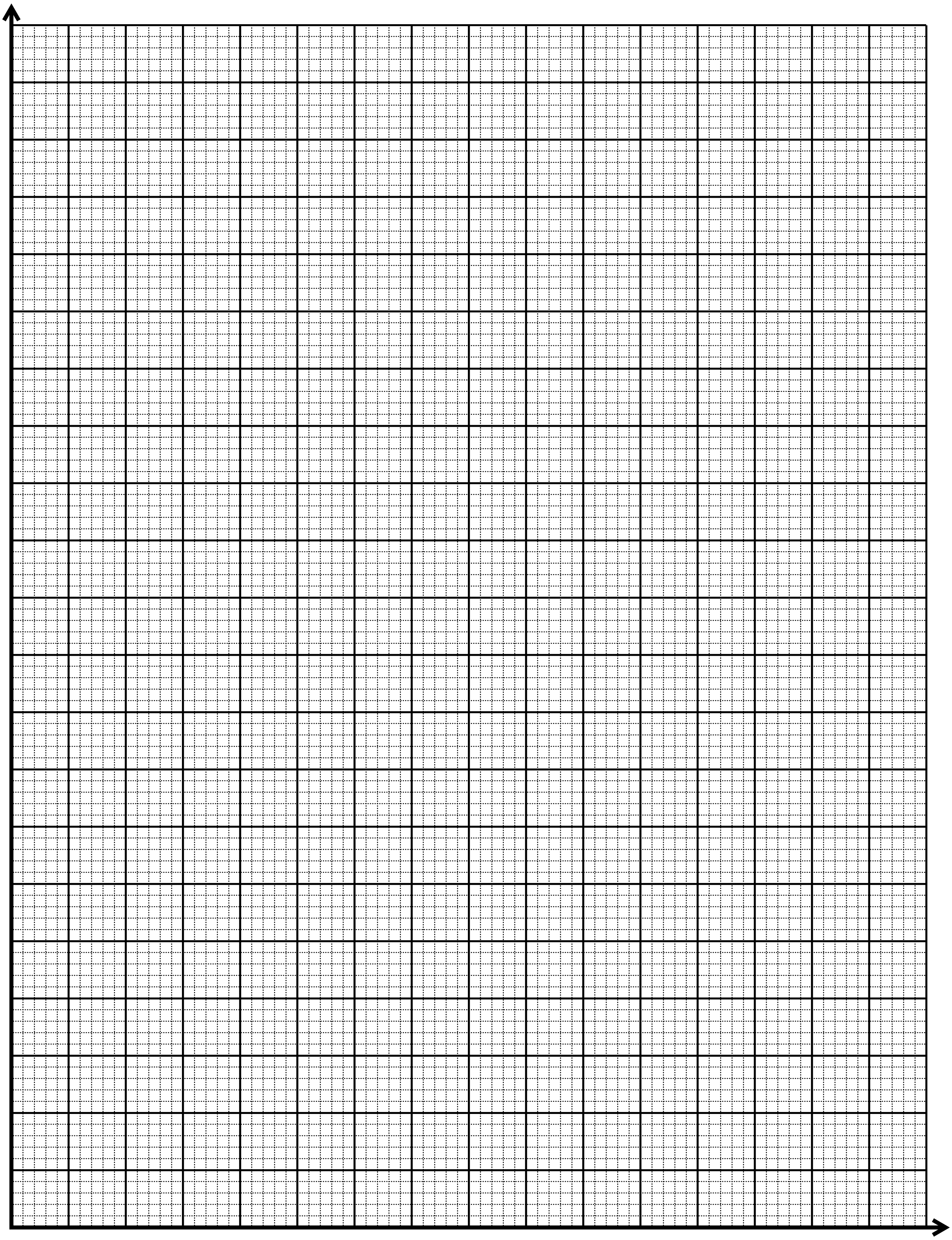

Figure 3. V_{AB} against L

(ii) It can be shown that for a certain range of values of R_x and the given values for the other components, the equation in Part (c) can be approximated to

$$V_{AB} = 4 - K \rho L,$$

where $K = 1.27 \times 10^5\ (m^{-2}\ V\ \Omega^{-1})$ and ρ is the resistivity of the coil wire.

Use this equation and your graph to determine ρ, the resistivity of the coil wire.

[4 marks]

Total 15 marks

2. (a) (i) Draw the circuit diagram for an inverting amplifier using an operational amplifier.

Label EACH resistor in your circuit with the conventional term used to describe it.

[3 marks]

(ii) State THREE properties of an ideal operational amplifier.

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[3 marks]

(b) A student conducted an experiment in which a variable voltage source was connected to the input of an inverting amplifier. The input voltage and the corresponding output voltage were measured using a multimeter and the readings obtained were recorded in Table 2.

TABLE 2: MULTIMETER READINGS

Input Voltage V_i (volts)	**Output Voltage V_o (volts)**
−0.21	2.20
0.00	0.00
0.38	−3.82
0.82	−8.18
1.17	−12.1
1.62	−15.0
2.44	−15.0

(i) On the grid provided in Figure 4 **(page 11)**, plot a graph of output voltage (V_o) vs input voltage (V_i).

[4 marks]

(ii) Use your graph to calculate the gain of the amplifier.

[2 marks]

(iii) Explain the shape of your graph.

[3 marks]

Total 15 marks

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Figure 4. Output voltage vs input voltage

3. (a) Technetium-99m is a commonly used radioisotope in nuclear medicine.

Complete Table 3 to indicate TWO properties and TWO reasons why a radioisotope such as technetium-99m can be used in this way.

TABLE 3: RADIOISOTOPE IN NUCLEAR MEDICINE

Property of Radioisotope	Reason for Use in Nuclear Medicine

[4 marks]

(b) (i) A sample of technetium-99m has an initial activity, A_o, of 50 GBq (Gigabecquerel). Its activity is measured at two-hour intervals and the results recorded as shown in Table 4. Complete the table by calculating and inserting appropriate values in the relevant columns.

TABLE 4: ACTIVITY OF TECHNETIUM-99M

Activity A (GBq)	A/A_0	$\ln(A/A_0)$	Time t (hr)
39.7			2.00
31.6			4.00
25.1			6.00
20.0			8.00
15.9			10.0
12.6			12.0

[2 marks]

(ii) On the grid provided in Figure 5 **(page 13)**, plot a graph of ln (A/A_0) against time, t (in hours), and draw the best straight line through the points.

[4 marks]

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Figure 5. ln (A/A_0) against time

(iii) Use your graph to find the decay constant of technetium-99m.

[3 marks]

(iv) Use the decay constant to calculate the half-life, $t_{1/2}$, of technetium-99m.

[2 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

SECTION B

Answer ALL questions.

Write your answers in the spaces provided.

4. (a) By using the formula $F = BIL\sin\theta$, define FULLY the unit of magnetic flux density, the tesla.

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[3 marks]

(b) (i) The heaters of an electric stove dissipate 5 kW when connected to a 110 d.c. source. Calculate the current drawn from the source.

[2 marks]

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(ii) The cable connecting the heating elements to the source consists of two parallel conductors encased in plastic insulation and separated by 0.5 cm as shown in Figure 6.

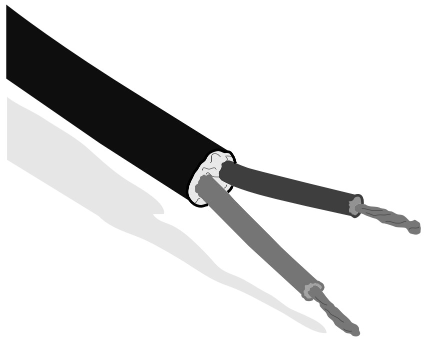

Figure 6. Two-wire high current cable

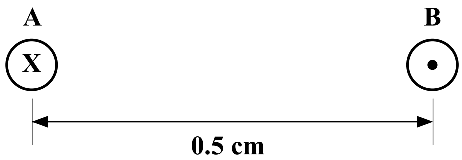

Figure 7. Current carrying conductors

Ignoring the effect of the insulation, the arrangement is approximately that of Figure 7 (not drawn to scale).

Redraw Figure 7 and add to your drawing a rough sketch of the magnetic field of the current in Conductor A. Indicate by an arrow on the diagram, the direction of the force experienced by Conductor B due to the magnetic field of the current in **A**.

[3 marks]

GO ON TO THE NEXT PAGE

(c) (i) Calculate the value of the magnetic field at **B** due to the current in **A**.

[2 marks]

(ii) Determine the magnitude and direction of the force experienced by EACH centimetre of Wire **B** due to the magnetic field of the current in Wire **A**.

[2 marks]

(d) The calculations carried out in (c) (i) and (c) (ii) ignore the effect of the insulating plastic sheath in which the copper conductors are encased. Deduce the effect that the plastic sheath would have on the magnetic field of the current in Wire **A** and give a reason for your answer.

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[3 marks]

Total 15 marks

5. (a) Draw the truth table for a 2-input NAND gate.

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[2 marks]

(b) Complete Table 5 for the circuit shown in Figure 8 and hence show that this circuit is equivalent to a NAND gate.

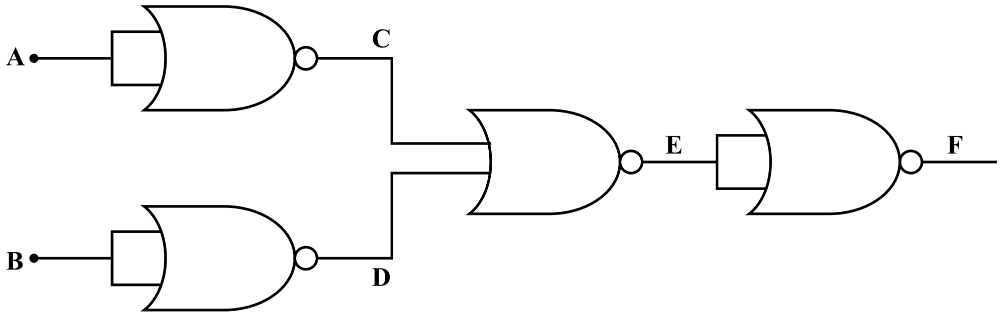

Figure 8. NAND gate equivalent

TABLE 5: LOGIC TABLE

A	B	C	D	E	F

[4 marks]

GO ON TO THE NEXT PAGE

(c) Draw the NAND gate version of an S-R flip-flop taking care to label all inputs and outputs.

[4 marks]

(d) The signals S and R shown in Figure 9 are simultaneously applied to the corresponding inputs of an S-R flip-flop. Determine and draw on Figure 9, the Q-output (indicates that the flip-flop is set) of the flip-flop for time intervals 1–5.

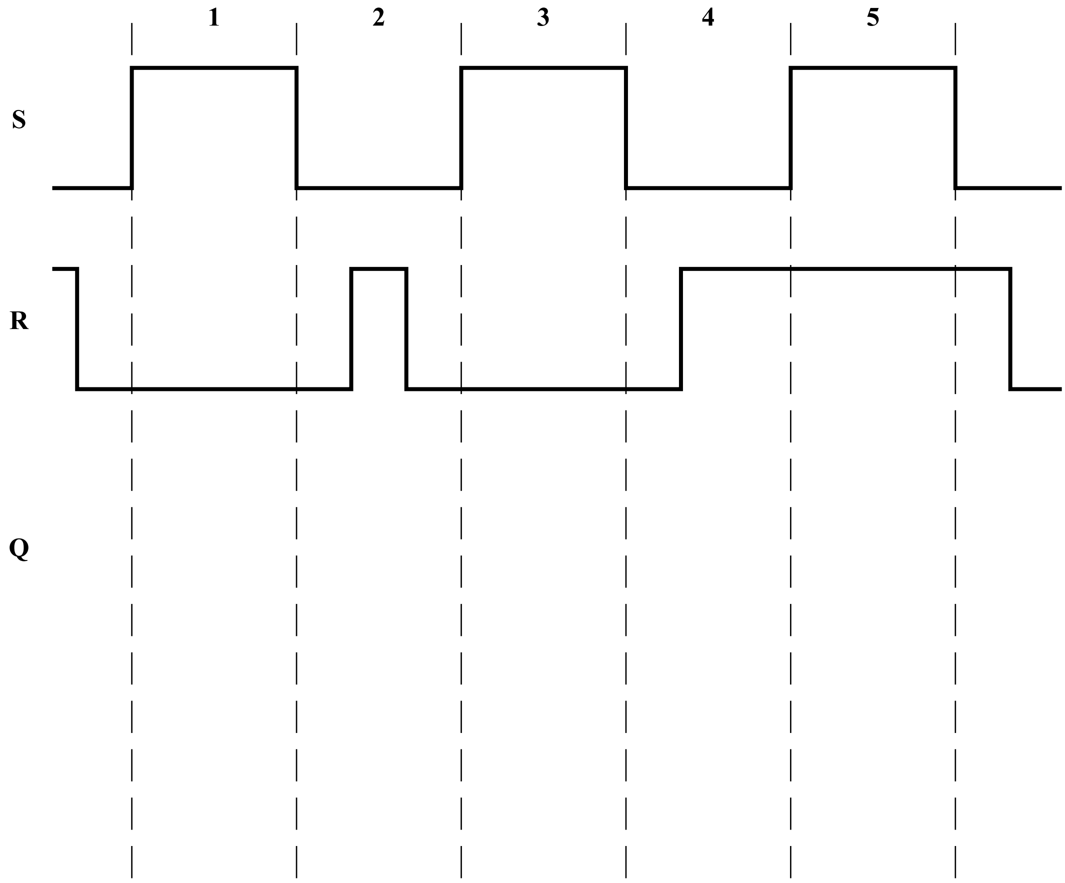

Figure 9. Timing diagram

[5 marks]

Total 15 marks

6. (a) State TWO conclusions regarding the nature of atomic structure that were deduced from the results of the Geiger–Marsden experiment.

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[2 marks]

(b) (i) Distinguish between the terms ‘mass defect’ and ‘binding energy’.

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[3 marks]

(ii) Sketch a graph to show the relationship between binding energy per nucleon and nucleon number.

[3 marks]

GO ON TO THE NEXT PAGE

(c) A scheme for the production of energy by nuclear fusion proposes to combine deuterium $\left({}^{2}_{1}H\right)$ and tritium $\left({}^{3}_{1}H\right)$ under conditions of high temperature and pressure to produce helium. The proposed reaction may be written as

$${}^{2}_{1}H + {}^{3}_{1}H \longrightarrow {}^{4}_{2}He + {}^{1}_{0}n + \Delta E.$$

The masses of the reactants and the products are:

${}^{2}_{1}H$ = 2.014102 u

${}^{4}_{2}He$ = 4.002602 u

${}^{3}_{1}T$ = 3.016049 u

${}^{1}_{0}n$ = 1.008665 u

(i) Calculate the mass defect in kilograms.

[4 marks]

(ii) Hence, calculate the energy in MeV which would be released in this reaction.

[3 marks]

Total 15 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

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MAY/JUNE 2015

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PHYSICS

UNIT 2 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. ALL working MUST be shown.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
6. You are advised to take some time to read through the paper and plan your answers.
7. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
8. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

1. In this experiment you will use the tossing of a number of coins to simulate radioactive decay.

You are provided with the following materials:

(1) A large table, covered to provide a soft surface
(2) A number of coins (approximately 150)
(3) A container with cover large enough to hold all the coins while shaking them

Procedure

(a) Count the coins and record their number, N_0.

N_0 = ... **[1 mark]**

(b) Place all the coins in the container provided. Shake the container vigorously to randomize the orientation of the coins then toss the coins on the table. Try to toss in such a way that the coins are spread out evenly. Where coins may lie on top of each other, spread them out manually taking care that none of them is turned over.

(c) Remove the coins showing heads and count the number, N_H. Record this number for the relevant coin toss sequence number, C_N, in Table 1.

TABLE 1: RADIOACTIVITY SIMULATION BY TOSSING COINS

Coin Toss Sequence Number (C_N)	**Number of Heads (N_H)**	**Heads Ratio (N_H/N_O)**	**ln (N_H/N_O)**
1			
2			
3			
4			
5			
6			
7			

(d) Put away the 'heads' coins — you will not need them again.

(e) Collect the remaining 'tails' coins and repeat Step (b). **[1 mark]**

(f) Repeat Steps (c) and (d) until seven values have been obtained. **[1 mark]**

(g) Calculate the values for Column 4 and complete Table 1. **[2 marks]**

(h) On the graph paper provided in Figure 1 **(page 3)**, plot a graph of ln (N_H/N_O) vs C_N, and draw the best straight line through the points. **[6 marks]**

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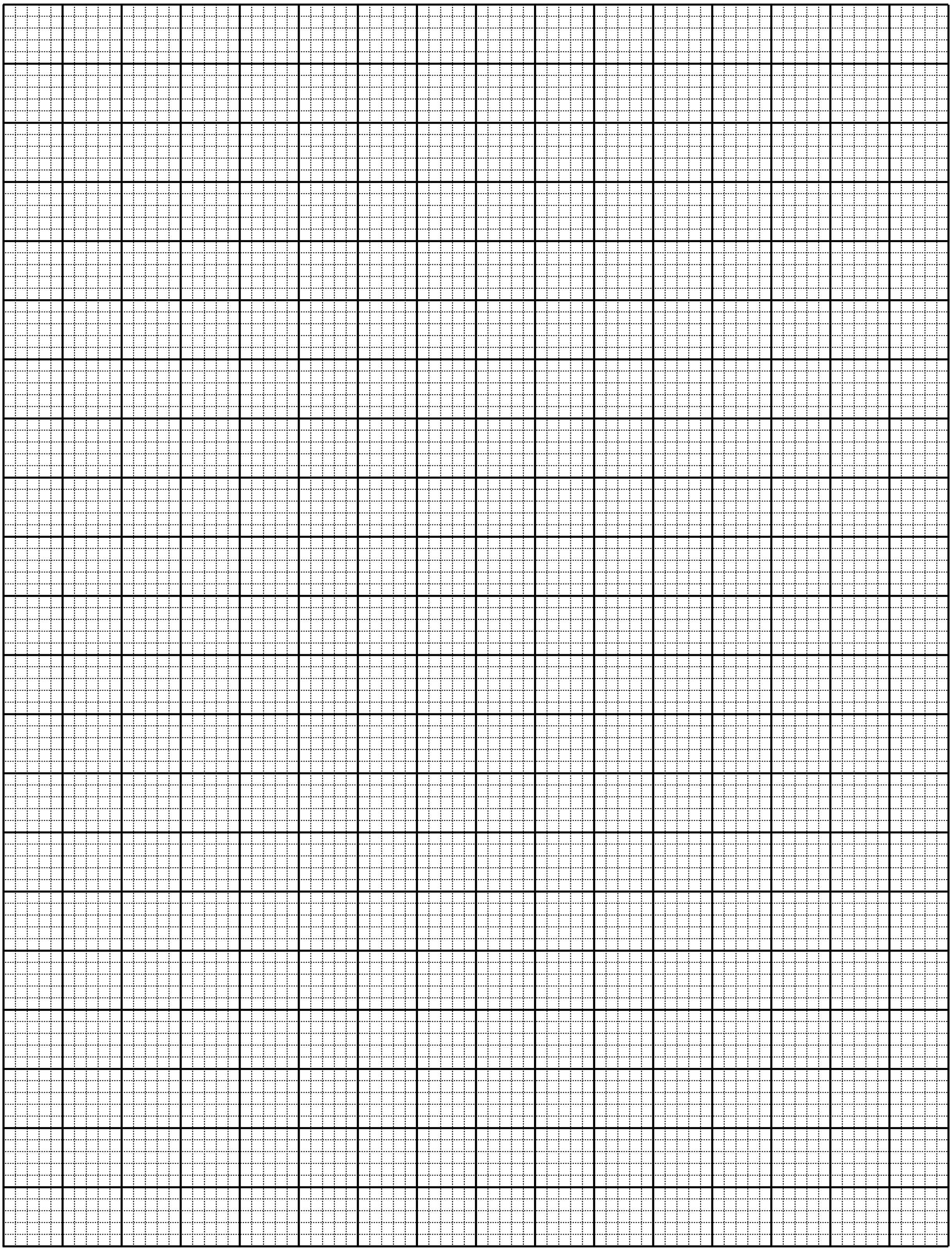

Figure 1. ln (N_H/N_O) vs C_N

(i) Calculate the slope of the line obtained in (h).

[3 marks]

(j) If your graph represents the simulation of a radioactive decay process, what would the variables C_N and N_H represent in that process?

[2 marks]

Total 16 marks

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2. The terminal voltage of a typical laboratory power supply decreases as the current drawn from it (that is, the load) increases. A measure of this performance characteristic is a quantity called the ‘ % regulation’, defined by

$$\% \text{ regulation} = \frac{\text{No load voltage} - \text{Full load voltage}}{\text{No load voltage}} \times 100$$

In an experiment to measure the regulation of a 6 V, 10 A power supply, the circuit shown in Figure 2 was used.

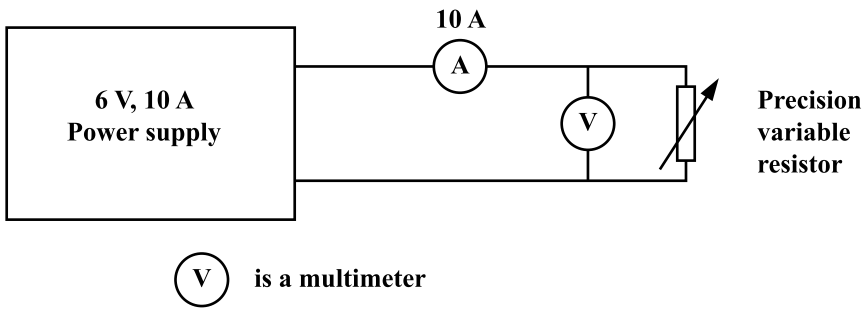

Figure 2. Circuit

The readings obtained from the ammeter and multimeter were recorded as shown in Table 2.

TABLE 2: AMMETER AND MULTIMETER READINGS

Output Current from Ammeter I_o**(A)**	**Output Voltage from Multimeter** V_o**(V)**
0.0	6.03
1.0	5.82
2.0	5.69
3.0	5.53
4.0	5.40
5.0	5.23
6.0	5.11

(a) On the grid provided in Figure 3 **(page 7)**, plot a graph of V_o vs I_o taking care to ensure that your I_o – axis extends to 10 A. Draw the best straight line through the points.

[6 marks]

(b) Extrapolate your line graph to determine the full-load output voltage, V_{FL}. **[2 marks]**

(c) Record the value of V_{FL}.

V_{FL} = ... **[1 mark]**

(d) The no-load voltage occurs when the current is zero. Extract and record the value V_{NL}.

V_{NL} = ... **[1 mark]**

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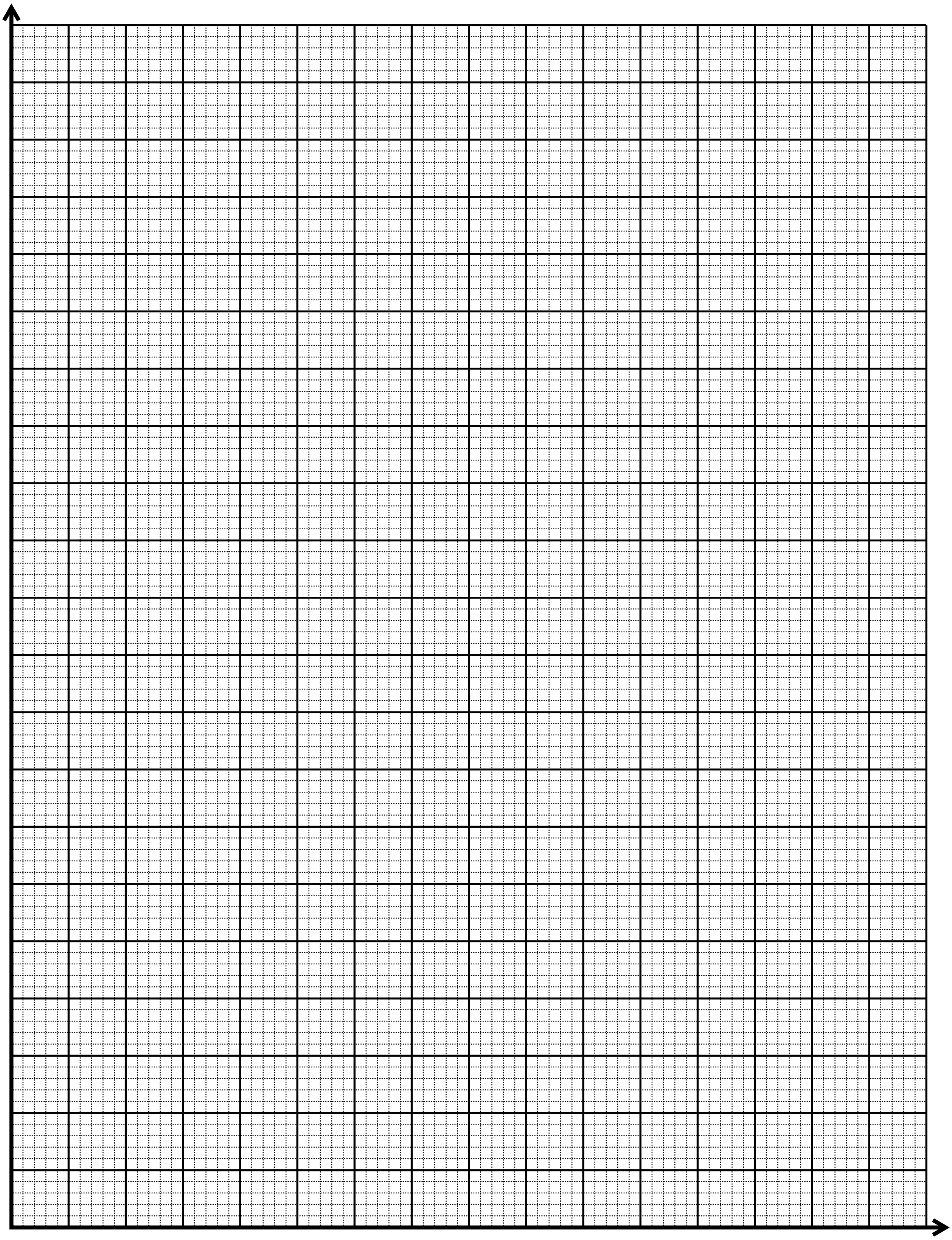

Figure 3. Output voltage versus output current

(e) Calculate the regulation of this power supply using

$$\% R = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100\%.$$

[2 marks]

(f) Calculate the power that would be drawn from this power supply when operating at full load.

[2 marks]

(g) Suggest TWO reasons why it might not be advisable to draw 10 A from the power supply in the experiment.

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[2 marks]

Total 16 marks

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3. A student suggested the following method for measuring the value of an unknown capacitance.

"Remove the two resistors from one of the parallel arms of a wheatstone bridge and replace them by two capacitors: a precision reference capacitor (C_1) and an unknown capacitor (C_2)".

Design an experiment to test the validity of this method using four test capacitors of known value to simulate the unknown capacitor and use the balance equation,

$$\frac{R_2}{R_1} = \frac{C_1}{C_2}$$

where the subscript '1' denotes a component in the upper half of the bridge. Use the following guidelines:

(a) List of additional apparatus required

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[1 mark]

(b) Circuit diagram

[3 marks]

GO ON TO THE NEXT PAGE

(c) Procedure

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[4 marks]

(d) Table of results

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[3 marks]

(e) Analysis

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[4 marks]

(f) Conclusion

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[1 mark]

Total 16 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

TEST CODE **02138020**

FORM TP 2016273

MAY/JUNE 2016

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PHYSICS

UNIT 1 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in TWO sections. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
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DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

“*”Barcode Area”*”
Sequential Bar Code

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	atm	=	1.00×10^5 N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water	ρ_w	=	1.00×10^3 kg m^{-3}
Specific heat capacity of water	C_w	=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice	L_f	=	3.34×10^5 J kg^{-1}
Specific latent heat of vaporization of water	L_v	=	2.26×10^6 J kg^{-1}
Avogadro's constant	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan–Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in free space (vacuum)	c	=	3.00×10^8 m s^{-1}
Planck's constant	h	=	6.626×10^{-34} J s
Triple point temperature	T_{tr}	=	273.16 K
1 tonne	t	=	1000 kg

SECTION A

Answer ALL questions.

Write your answers in the spaces provided.

1. (a) (i) Define the term 'acceleration' and state its units.

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[1 mark]

(ii) State Newton's second law of motion in words AND the associated equation.

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[3 marks]

(b) A car is travelling along a level road at a speed of 15 m s^{-1} towards a set of traffic lights when the light turns red. In 0.5 seconds after seeing the light, the driver applies the brakes and brings the car to a stop at the traffic lights. Table 1 shows how the speed of the car changes from the time the driver sees that the traffic lights turn red.

TABLE 1

Time/s	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Speed/m s^{-1}	15.0	15.0	12.5	10.0	7.5	5.0	2.5	0.0

(i) On the grid provided in Figure 1 **(page 7)**, plot a graph of speed against time.

[5 marks]

(ii) Suggest a reason why the velocity remains unchanged for the first 0.5 seconds after the light turns red.

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[1 mark]

(iii) What feature of the graph shows that the car's deceleration was uniform?

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[1 mark]

(iv) Use your graph to determine the distance that the car travelled after the lights turned red to when the car stopped.

[4 marks]

Total 15 marks

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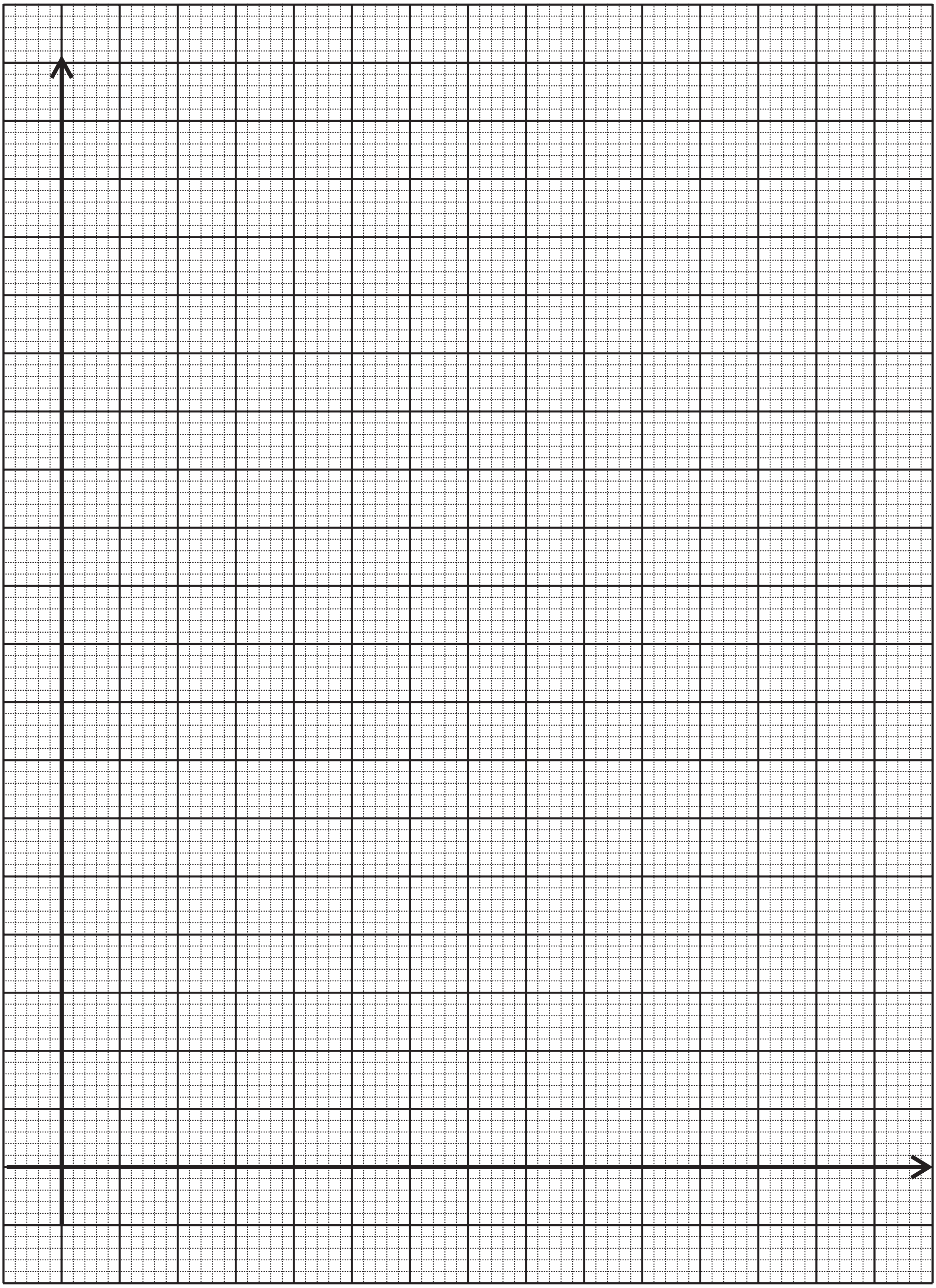

Figure 1. Speed versus time

2. (a) A transverse progressive wave travels along a stretched string from left to right. The shape of part of the string at a particular instant is shown in Figure 2. The frequency of the wave is 15 Hz.

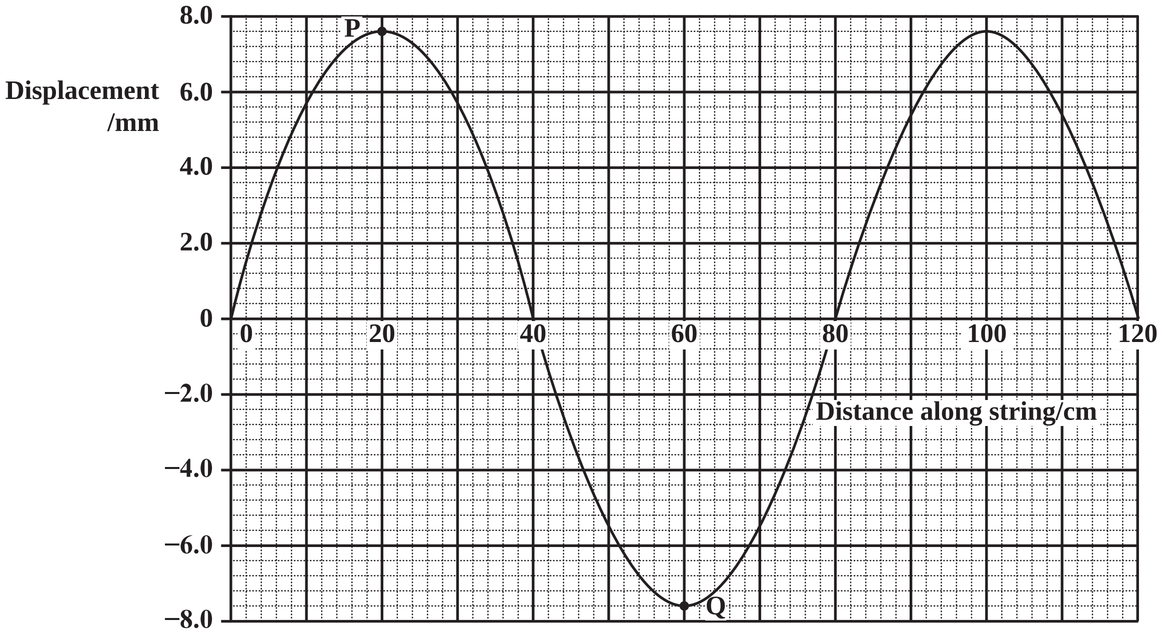

Figure 2. Transverse progressive wave along string

Use Figure 2 to determine, for this wave, its

(i) amplitude

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[1 mark]

(ii) phase difference between Points P and Q on the string

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[1 mark]

(iii) speed.

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[2 marks]

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(b) Another stretched string is used to form a stationary wave. A part of this wave at a particular instant is shown in Figure 3. The points on the string are at their maximum displacement.

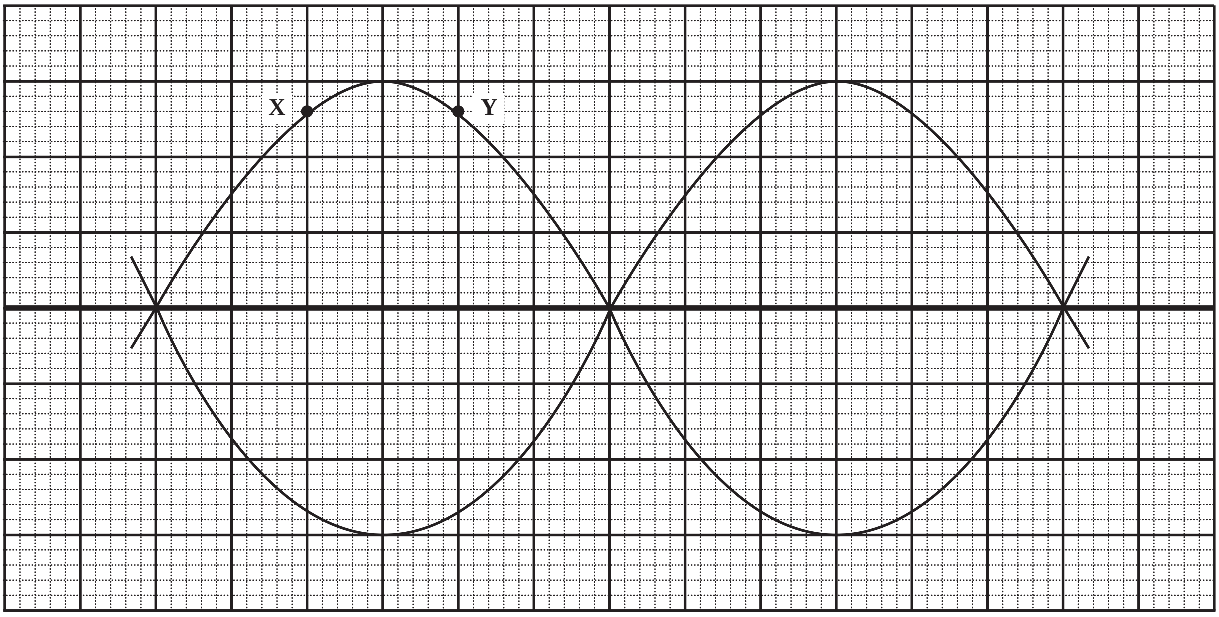

Figure 3. Stationary wave

(i) State the phase difference in the motion of the points on the string labelled X and Y.

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[1 mark]

(ii) Distinguish between the terms 'antinode' and 'node' when used to describe stationary waves on a string.

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[2 marks]

(iii) State the number of antinodes shown on Figure 3.

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[1 mark]

(c) Table 2 shows how the wavelength produced on a stretched string changes as the wave speed is varied.

TABLE 2

Wave Speed v/m s^{-1}	**Wavelength** λ/m
05	0.06
10	0.12
15	0.18
20	0.24
25	0.30
30	0.36
35	0.42
40	0.48

(i) On the grid provided in Figure 4 **(page 11)**, plot a suitable graph to respresent the data. **[5 marks]**

(ii) Hence, determine the frequency of the standing wave.

[2 marks]

Total 15 marks

Figure 4. Wavelength versus wave speed

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3. (a) After a lesson on Hooke's law, a student is asked to measure the mass of a rock sample using a steel spring, standard masses and a metre rule. The student measured the unstretched length of the spring and then set up the arrangement shown in Figure 5.

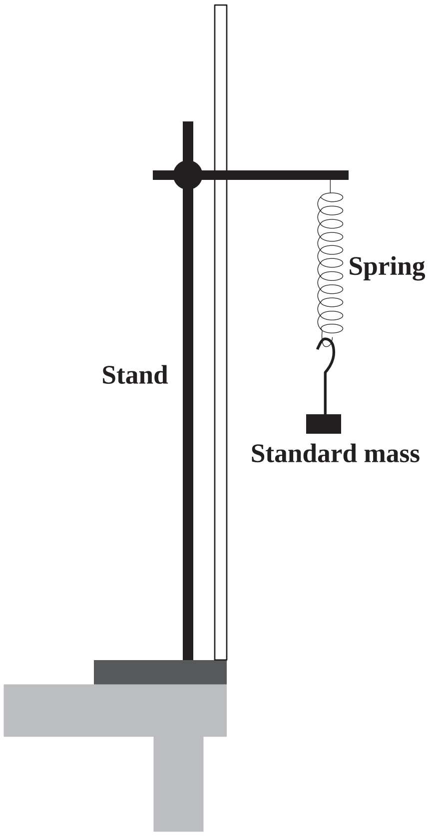

Figure 5. Arrangement for measuring the mass of a rock sample

(i) State Hooke's law.

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[2 marks]

(ii) Describe how this arrangement could be used to determine the spring constant and hence, the mass of the rock sample.

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[6 marks]

(b) A spring manufacturer tests the properties of a spring by measuring the load applied each time the extension is increased. The graph of load versus extension is shown in Figure 6.

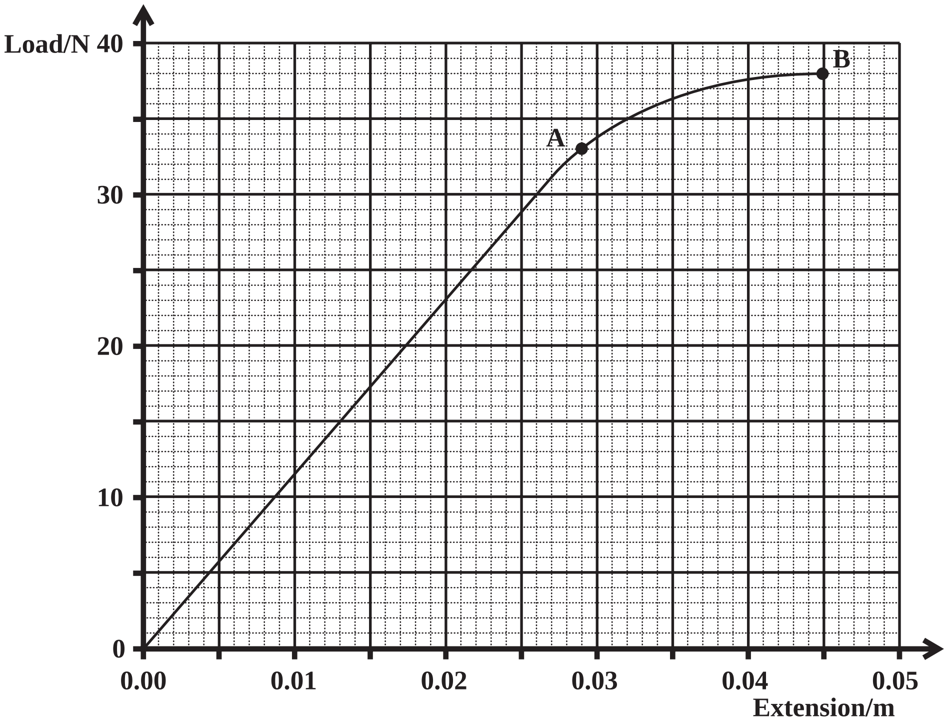

Figure 6. Load versus extension

(i) Use the graph to find the work done in extending the spring up to Point B.

[5 marks]

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Sequential Bar Code

(ii) Beyond Point A, the spring undergoes inelastic deformation. Explain the term 'inelastic deformation'.

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[2 marks]

Total 15 marks

SECTION B

Answer ALL questions.

Write your answers in the spaces provided.

4. (a) By referring to Figure 7, explain the origin of upthrust and how upthrust determines whether an object will float or sink.

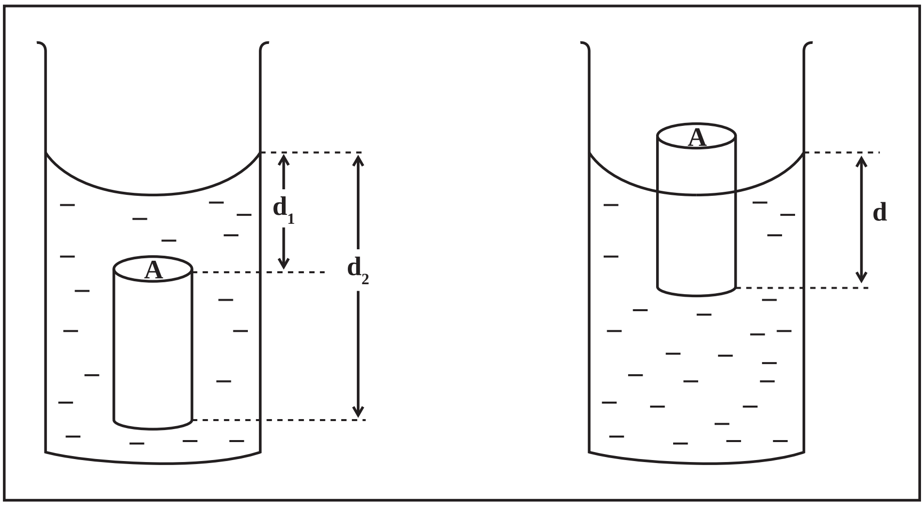

Figure 7. Upthrust

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[5 marks]

(b) In the experiment illustrated in Figure 8, it was found that the weight of the stone in air is 1.0 N and the weight when the stone was totally immersed in water was 0.75 N.

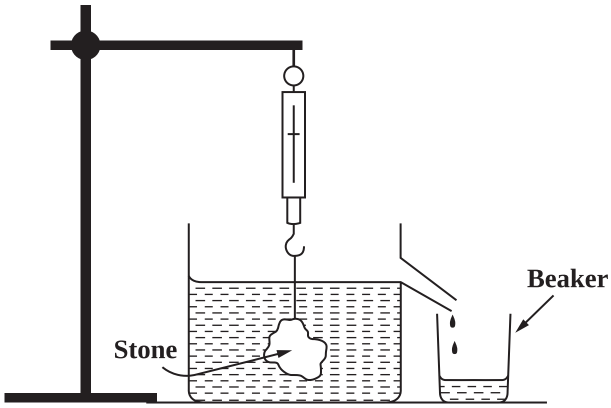

Figure 8. Weight of stone

(i) Determine the weight of water that would be collected in the beaker.

[1 mark]

(ii) For (b) (i), calculate the volume of water displaced and hence, determine the density of the stone.

[3 marks]

(c) In the experiment shown in Figure 9, it was found that the reading on the spring balance changed from 2.1 N to 1.8 N as the metal ornament was lowered into the measuring cylinder containing water. The height of water in the cylinder rose from the 50 cm^3 mark to the 80 cm^3 mark. When the cylinder contained corn oil instead of water, it was found that the height of oil rose by the same amount (as when in water), but the reading on the spring balance changed from 2.1 N to 1.87 N.

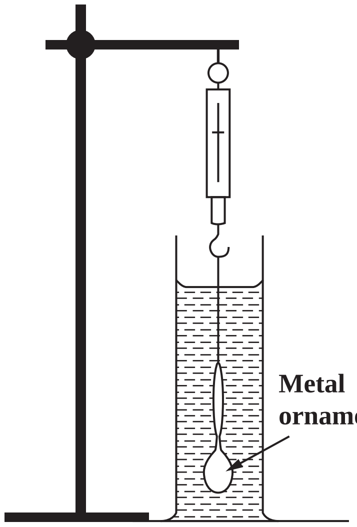

Figure 9. Spring balance

(i) State the reason why the height of liquid in the measuring cylinder rose by the same amount.

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[1 mark]

(ii) Outline the reason why the reading on the spring balance was lower when the ornament was immersed in water than when it was immersed in corn oil.

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[1 mark]

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(iii) Calculate the density of the corn oil.

[4 marks]

Total 15 marks

5. (a) Briefly describe a laboratory experiment to prove Snell's law. Indicate any precautionary measures that must be taken during this experiment.

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[7 marks]

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(b) Three transparent glass blocks, A, B and C, are arranged **(not to scale)** as shown in Figure 10. Each glass block has a different refractive index.

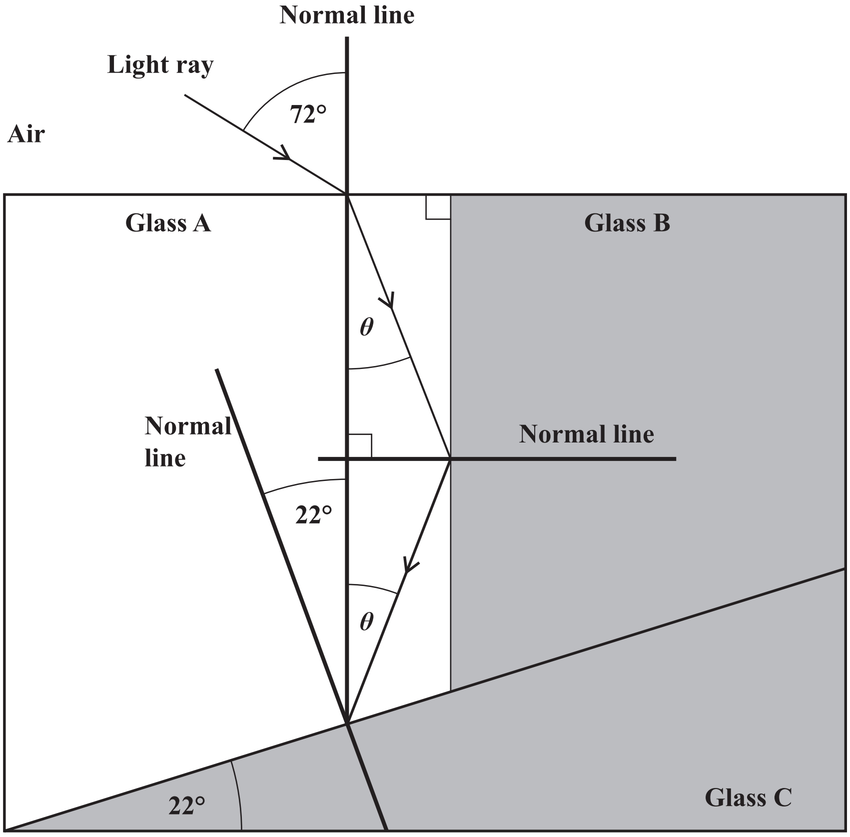

Figure 10. Arangement of transparent glass blocks

(i) Calculate the speed of light in Glass Block A.

(Refractive index of Glass Block A = 1.80.)

[2 marks]

(ii) Show that the angle θ in the figure is approximately 30 degrees.

[2 marks]

(iii) The refractive index of Glass Block C is 1.40. Calculate the critical angle between Glass Block A and Glass Block C.

[2 marks]

(iv) State what happens to the light when it reaches the boundary between Glass Block A and Glass Block C. Justify your answer.

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[2 marks]

Total 15 marks

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6. (a) Explain how the ‘greenhouse effect’ contributes to the warming of the Earth’s atmosphere.

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[6 marks]

(b) A rectangular glass window in an office building has dimensions 2.4 metres by 2 metres by 3 centimetres. The temperature of the outer surface of the window is 35 °C and the temperature of the inner surface is 26 °C.

(Assume the thermal conductivity of glass is 0.96 W/m/K.)

Calculate the rate of heat conduction through the glass.

[5 marks]

(c) The temperature in the room is maintained at 26 °C by an air conditioning unit. If the air conditioning unit fails, determine how long it will take for the temperature of the room and its contents to increase by 3 °C.

(Assume that heat conduction is the only source of heat input to the room; the average heat capacity of the room and its contents is 5.7×10^5 J/ °C.)

[4 marks]

Total 15 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

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C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 1 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. Where appropriate, ALL WORKING MUST BE SHOWN in this booklet.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
6. You are advised to take some time to read through the paper and plan your answers.
7. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
8. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

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Sequential Bar Code

NOTHING HAS BEEN OMITTED.

Answer ALL questions.

Write your answers in the spaces provided in this booklet.

1. In this activity you will investigate the oscillations of a chain of paper clips. You are provided with the following: 30–35 paper clips, clamp, cork with hook and a stopclock. The procedure is outlined below.

Procedure:

1. Firmly clamp the cork using a clamp, boss and stand.

2. Attach a chain of n paper clips to the hook as shown in Figure 1 with an initial value of $n = 24$.

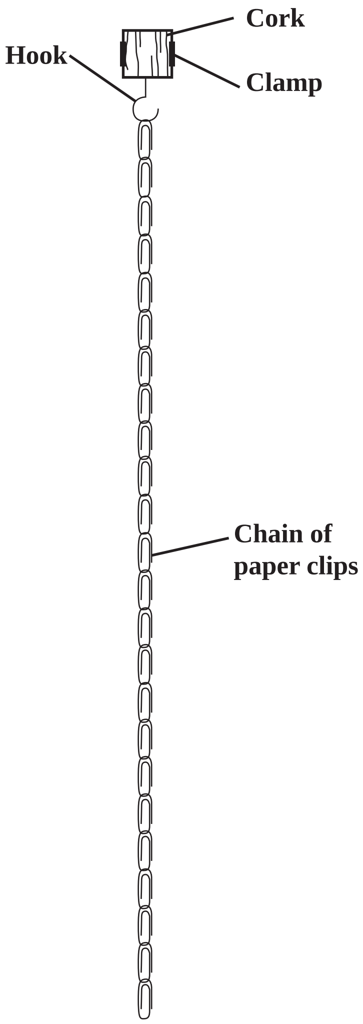

Figure 1. Oscillation of paper clips

3. Displace the chain from its equilibrium position by moving the bottom clip sideways.

4. When the chain is oscillating smoothly, measure and record the time, t, for 20 oscillations.

5. Vary the value of n ($25 > n > 5$), and repeat Steps 3 and 4 until you have six sets of readings for t and n.

(a) Record your data in Table 1.

TABLE 1

Number of Paper Clips (*n*)	**Time for 20 Oscillations (*t* seconds)**	**$T = t/20$ (secs)**	**ln *T***	**ln *n***

[6 marks]

(b) For this oscillator, it is suggested that the quantities T and n are related by a simple power law of the form $T = \text{p}\, n^{q}$, where p and q are constants. Assuming that the proposed power law is acceptable, plot a suitable graph on the grid provided in Figure 2 **(page 7)**.

[5 marks]

(c) Use your graph to determine the values of p and q.

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[5 marks]

Total 16 marks

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Figure 2. Power law

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2. A student is interested in determining the Young's modulus of a piece of nichrome alloy wire. He sets up the apparatus as shown in Figure 3 and takes repeated measurements of force, *f*, and the corresponding extension, *e*.

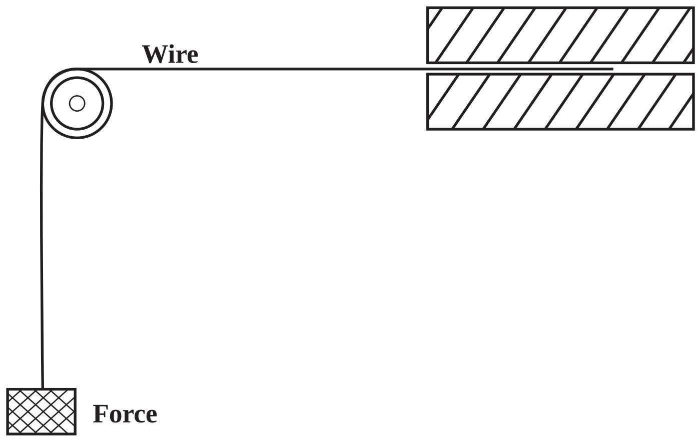

Figure 3. Determining Young's modulus

The cross sectional area, *A*, of the wire is 8.0×10^{-6} m^2 and the length of the wire used by the student in this experiment is 0.35 m. The values for the force and corresponding extensions are recorded in Table 2.

TABLE 2

Force/*N*	**Stress/*N m*$^{-2}$ (× 10^5)**	**Extension/*m* (× 10^{-5})**	**Strain (× 10^{-4})**
6.8		1.3	
9.2		4.3	
11.2		8.8	
13.6		13.1	
15.2		18.0	
18.4		23.6	
20.0		29.3	
22.8		34.1	
25.2		39.4	

(a) Complete Table 2 by inserting the appropriate values in Columns 2 and 4. **[6 marks]**

(b) On the grid provided in Figure 4 on **page 10**, plot a graph of stress versus strain, and draw the best fit line. **[6 marks]**

(c) Use your graph to determine the Young's modulus of nichrome alloy.

[3 marks]

(d) State ONE precaution that the student should take in performing this experiment.

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[1 mark]

Total 16 marks

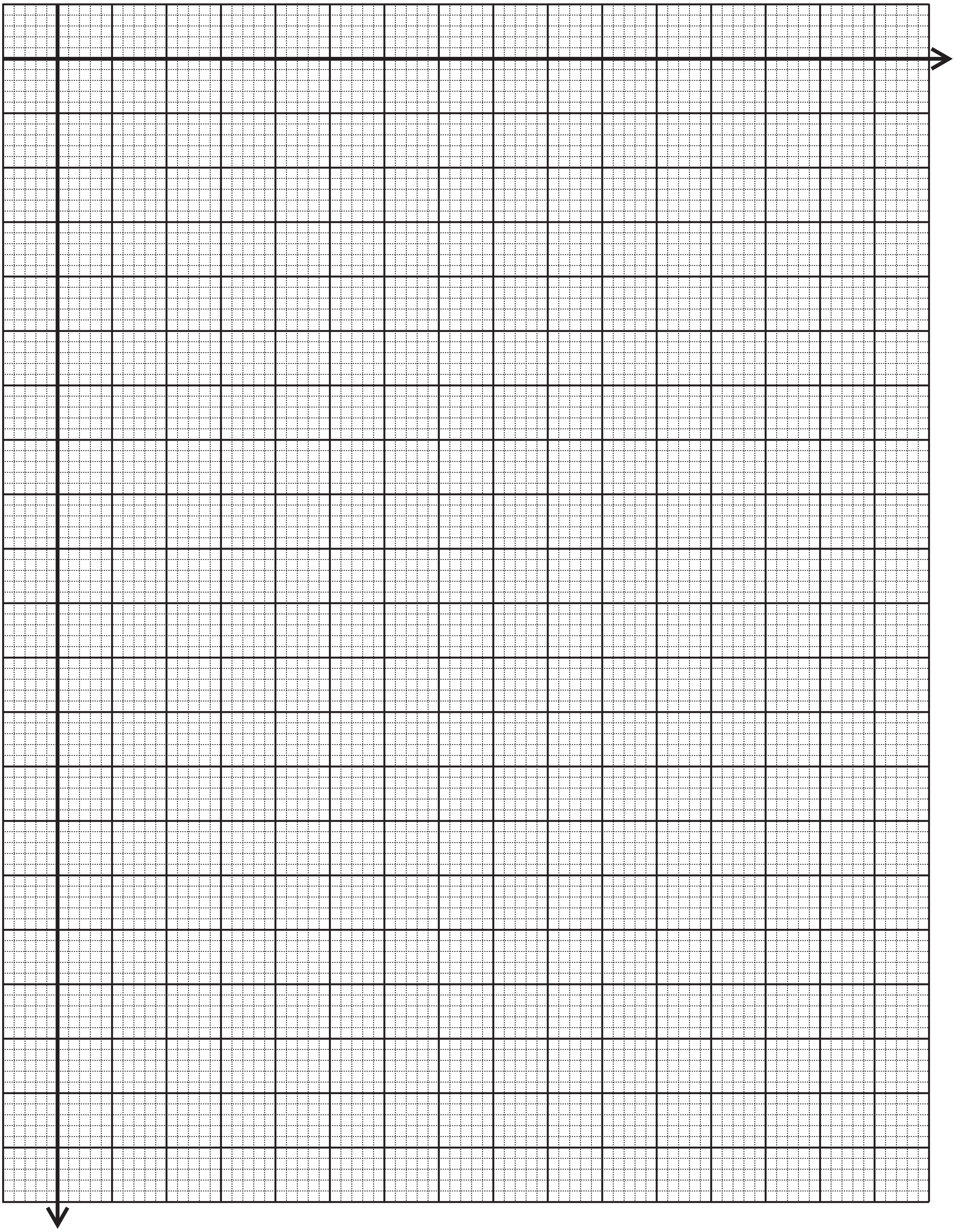

Figure 4. Stress vs Strain

3. It is believed that the speed of an object is affected by its size when it moves through liquid. In a laboratory, this can be modelled by dropping small steel balls through oil. It is further suggested that the velocity, v, with which the steel ball moves through the oil may be related to its radius, r, by the equation, $v = kr^2$, where k is a constant.

Design a laboratory activity to investigate whether v is related to r as indicated in the equation above. Include a diagram to show the arrangement of the equipment to be used, and an appropriate table to record the results.

(a) List of apparatus to be used

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[3 marks]

(b) Diagram of the arrangement

[2 marks]

(c) The procedure to be followed (including any precautions necessary)

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(d) Results

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(e) Analysis of data

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[3 marks]

Total 16 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

TEST CODE **02238020**

FORM TP 2016276

MAY/JUNE 2016

C A R I B B E A N E X A M I N A T I O N S C O U N C I L

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in TWO sections. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. Where appropriate, ALL WORKING MUST BE SHOWN in this booklet.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
6. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
7. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

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LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
	$\frac{1}{4\pi\,\varepsilon_0}$	=	9.0×10^{9} m F^{-1}
Elementary charge	e	=	1.60×10^{-19} C
Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Energy equivalence	$1\,u$	=	931 MeV/c^2
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Answer ALL questions.

Write your answers in the spaces provided.

1. (a) (i) Explain how terminal potential difference, internal resistance and ideal source are related in a practical source of electromotive force (e.m.f.) such as an alkaline battery.

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[3 marks]

(ii) State TWO qualitative practical observations which demonstrate the existence of internal resistance.

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[2 marks]

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(b) In an experiment to determine the internal resistance of a 9 V alkaline battery, a precision resistance box is connected to the battery through a digital multimeter (DMM) set up as an ammeter. The circuit is shown in Figure 1.

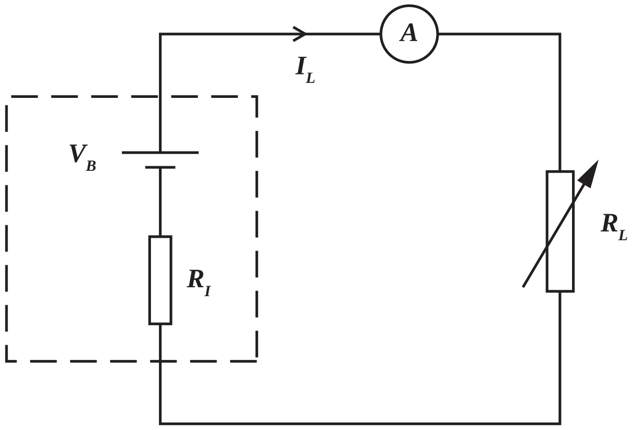

Figure 1. Circuit of resistance box

(i) Measurements of current, I_L, are recorded as the external resistance, R_L, is varied. Show that for this circuit, the relationship between the measured current, I_L, and the external resistance, R_L, can be expressed by the equation

$$R_L = I_L^{-1} V_B - R_I.$$

[2 marks]

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(ii) The results of the experiment are shown in the first two columns of Table 1.

TABLE 1

R_L/Ohms	**I_L/Amps**	**$(I_L)^{-1}$/Amp^{-1}**
4.1	0.78	
5.9	0.67	
8.1	0.58	
10.3	0.51	
12.0	0.46	

Complete Table 1 by inserting the appropriate values in Column 3. **[1 mark]**

(iii) On the grid provided in Figure 2 **(page 9)**, plot a graph of I_L^{-1} versus R_L and draw the best straight line through the points. Choose appropriate scales to ensure that the origin is included. **[4 marks]**

(iv) Determine and record the intercept on the I^{-1}_L axis.

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[1 mark]

(v) Use the intercept along with the equation given in (b) (i) to determine the internal resistance of the battery.

[2 marks]

Total 15 marks

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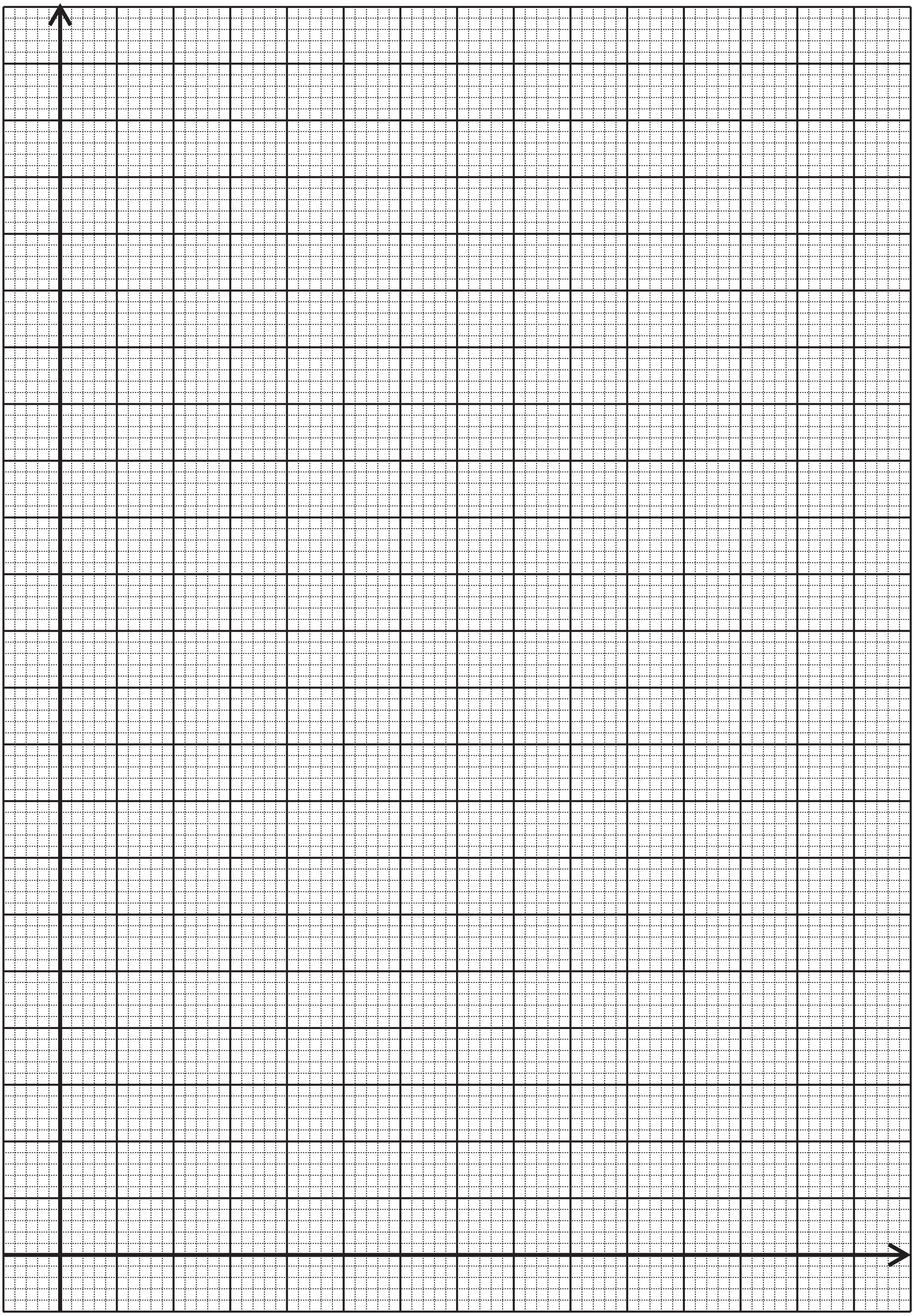

Figure 2. I_L^{-1} **versus** R_L

2. (a) Draw the circuit diagram and derive the expression for the gain of a non-inverting amplifier.

[6 marks]

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(b) The circuit shown in Figure 3 is used in a tester for resistive transducers where the variation in resistance of the transducer is converted to a variation in voltage. R_x is a test resistor used to simulate the transducer.

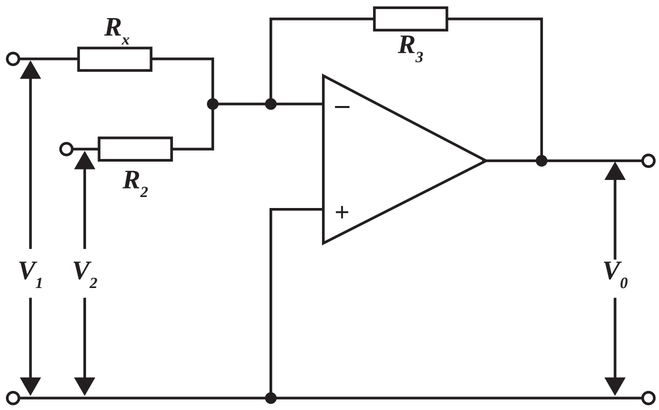

Figure 3. Circuit of tester

Show that output voltage V_0 and R_x are related by the equation

$$V_0 = 30\,000\, R^{-1}_{x} - 10, \text{ where}$$

$R_3 = R_2 = 10\ k\Omega$, $R_1 = R_x$, $V_2 = 10$ V and $V_1 = -3$V.

[2 marks]

(c) An experiment is carried out on the circuit shown in Figure 3 **(page 11)** in which the output voltage V_0 is monitored and recorded while R_x is varied over the range of values in Table 2.

TABLE 2

$R_x(k\Omega)$	$R^{-1}_x(10^{-3})$	V_0/V
2.0		6.0
3.0		1.0
4.0		–1.5
5.0		–3.0
6.0		–4.0

(i) Complete Table 2 by inserting the appropriate values in Column 2. **[1 mark]**

(ii) On the grid provided in Figure 4 **(page 13)**, plot a graph of V_0 versus R^{-1}_x and draw the best straight line through the points. **[4 marks]**

(d) Use your graph to determine the value of R_x which results in zero output voltage.

[2 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

Figure 4. V_0 versus R_x^{-1}

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NOTHING HAS BEEN OMITTED

3. (a) X-rays are weakened by their passage through matter. Write the equation which quantifies this phenomenon, and state the meaning of EACH term in your equation.

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[4 marks]

(b) Figure 5 is a schematic diagram of a setup which is used to measure the attenuation produced in a beam of x-rays by metal samples of different thickness.

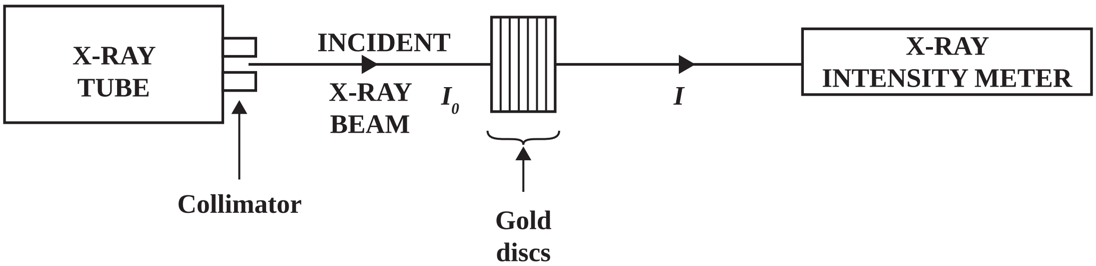

Figure 5. Setup to measure attenuation

In such a measurement, a beam of x-rays is directed at a target consisting of several thin gold discs of equal thickness of 0.4 mm. The ratio of emerging intensity, I, to incident intensity, I_0, is recorded in Table 3 **on page 16**.

GO ON TO THE NEXT PAGE

TABLE 3

Attenuation (I/I_0)	**Number of Discs**	**$\ln(I/I_0)^{-1}$**	**Total Thickness (mm)**
1.00	0		
0.55	1		
0.30	2		
0.15	3		
0.09	4		
0.05	5		

(i) Complete Table 3 by inserting the relevant values in Columns 3 and 4. **[3 marks]**

(ii) On the grid provided in Figure 6, **(page 17)**, plot a graph of the natural log of attenuation, $\ln(I/I_0)$ versus total thickness. **[4 marks]**

(iii) Use your graph to determine the linear absorption coefficient of gold in cm^{-1} at the wavelength of the incident photons.

[3 marks]

(iv) Suggest a reason why the linear absorption coefficient of a metal would decrease with decreasing wavelength of the incident beam.

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[1 mark]

Total 15 marks

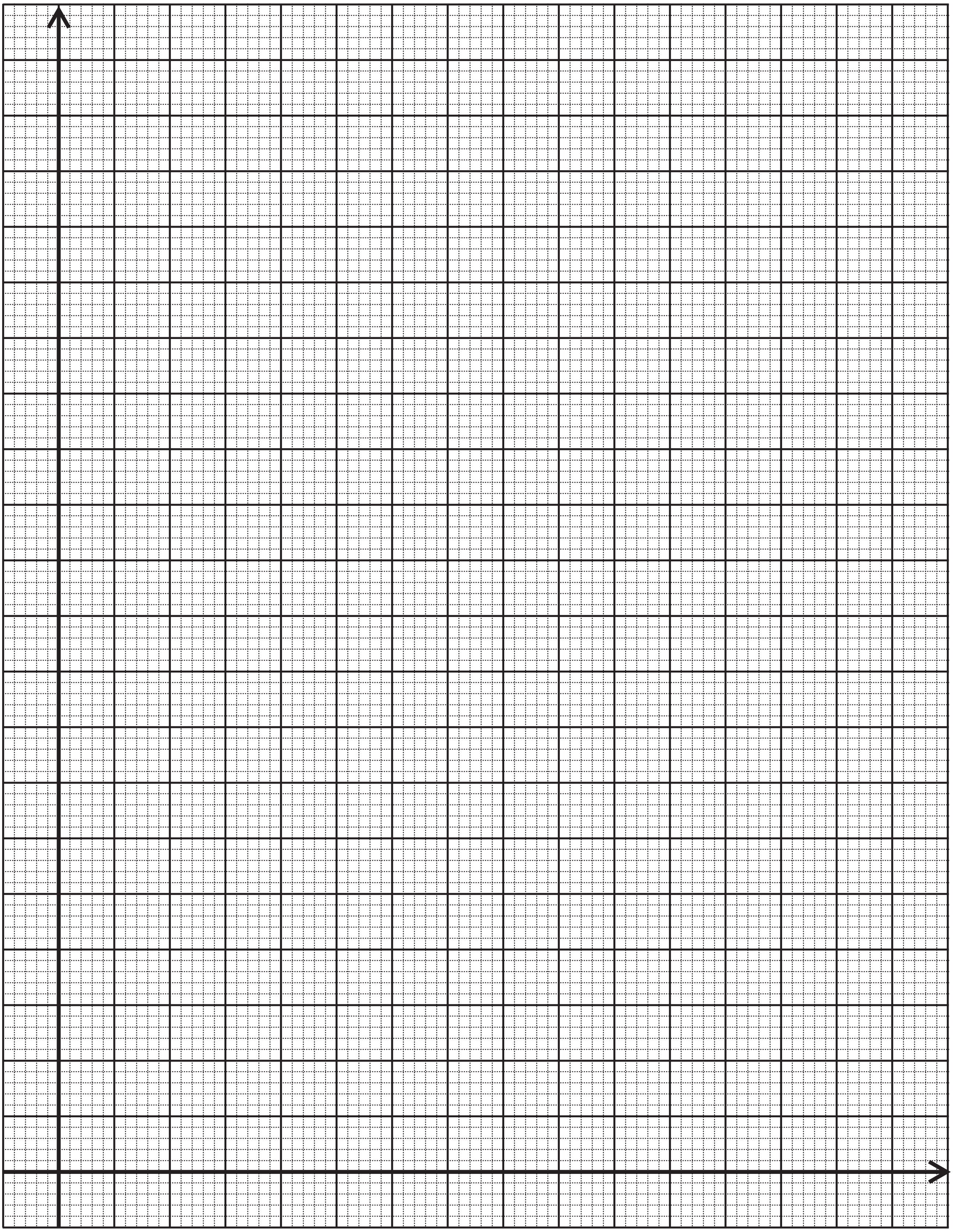

Figure 6. **ln(I/I_0) versus total thickness**

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SECTION B

Answer ALL questions.

Write your answers in the spaces provided.

4. (a) Explain the term ‘drift velocity’ when applied to the movement of electrons in a conductor.

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[2 marks]

(b) Write the meaning of EACH variable in the following equation and state the unit in EACH case.

$$I = nevA.$$

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[4 marks]

(c) A cylindrical copper wire has the following specifications at ambient temperatures.

The wire carries a current of 6 A,

Radius = 6.9×10^{-4} m; Free electron density = 6.5×10^{28} m^{-3}.

(i) Calculate the drift velocity of electrons in the wire in **millimetres per second**.

[5 marks]

(ii) Suggest a reason why this value is so small compared to the other values of electron velocity commonly encountered in physics.

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[2 marks]

(iii) Would the drift velocity in a semiconductor material of similar dimensions carrying the same current be greater than that of the conductor in (c) (i)? State a reason for your answer.

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[2 marks]

Total 15 marks

5. (a) (i) With the aid of a diagram, explain the operation of a simple half-wave rectifier circuit which employs a junction diode. Indicate the polarity of the output voltage on the diagram.

[6 marks]

(ii) Sketch the output voltage when the input is a sine wave.

[1 mark]

(b) The voltage of the public electricity supply in some Caribbean countries can be described by the equation $V = 156 \sin 314\, t$.

For such a supply voltage, determine

(i) the peak voltage

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[1 mark]

(ii) the frequency

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[2 marks]

(iii) the root mean square (rms) voltage.

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[2 marks]

(c) Draw a labelled sketch (do not plot) showing the correct values of amplitude and period for two cycles of the output voltage when this waveform is applied to a simple half-wave rectifier circuit.

[3 marks]

Total 15 marks

6. (a) Describe the Geiger–Marsden experiment and discuss the evidence it provides for the nuclear model of the atom.

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[8 marks]

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(b) Cobalt-60 is an artificially produced isotope of Cobalt obtained by irradiating natural Cobalt-59 with fast neutrons from a nuclear reactor or similar source. Cobalt-60 is unstable and emits a beta particle and forms nickel. (Atomic numbers: Co – 27, Ni – 28)

Complete the following nuclear equations for this process.

Equation I: Co + n $\longrightarrow$

Equation II: $\longrightarrow$

[2 marks]

(c) Cobalt-60 has a half-life of 5.27 years. Beginning with an initial sample of 200 grams of pure Co-60, determine how many grams of nickel would be found after three years.

Neglect the mass equivalence of the energy in the radiated decay products.

[5 marks]

Total 15 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

FORM TP 2016277

TEST CODE **02238032**

MAY/JUNE 2016

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 2 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. Where appropriate, ALL WORKING MUST BE SHOWN in this booklet.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
6. You are advised to take some time to read through the paper and plan your answers.
7. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
8. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

“*”Barcode Area”*”
Sequential Bar Code

Answer ALL questions.

Write your answers in the spaces provided in this booklet.

1. (a) An ideal silicon diode is a device which has infinite resistance and therefore conducts no current when reverse biased. The ideal silicon diode also has a constant voltage drop of 0.7 V when forward biased and conducting.

Sketch the I–V characteristic of an ideal silicon diode.

[2 marks]

(b) In this experiment you will investigate how closely the forward bias characteristic of a real silicon diode approximates ideal behaviour.

You are provided with the following:

1. An assortment of resistors
2. 9 V battery with battery terminal connector
3. 1 N 4001 silicon diode
4. Digital multimeter (DDM)
5. Signal generator
6. SPST switch

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Procedure:

1. Set up the circuit shown in Figure 1 using the HIGHEST value resistor as load and making sure that the switch is in the open position.

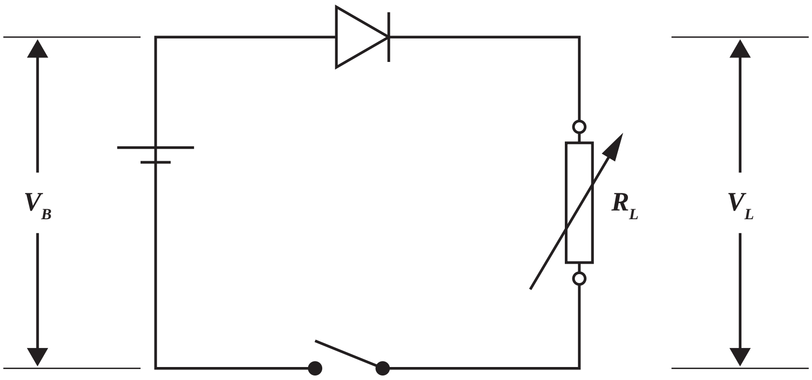

Figure 1. Silicon diode circuit

2. Close the switch and use your multimeter to measure the voltages V_L and V_B across the resistor and battery respectively.

3. Record the voltages V_L and V_B, and the resistance R_L in Table 1.

TABLE 1

R_L (Ω)	V_L (Volts)	V_B (Volts)	$I_D = V_L/R_L$ (mA)	$V_D = V_B - V_L$ (Volts)

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4. Open the switch, remove the resistor and replace it with the NEXT LOWEST value.

5. Repeat Steps 2–4 with all the resistors provided. **[3 marks]**

(i) Calculate I_D and V_D and enter the results in Columns 4 and 5 of Table 1 **(page 5)**. **[2 marks]**

(ii) On the grid provided in Figure 2 **(page 7)**, plot a graph of I_D versus V_D, and draw your best smooth curve through the points. **[5 marks]**

(iii) Draw the tangent to the curve at the HIGHEST value I_D recorded in Step 5 of the procedure. **[1 mark]**

(iv) Determine and record the value of V_{D0} at the point where the tangent intersects the *V*-axis.

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[1 mark]

(v) Compare the value of V_{D0} obtained in (iv) above with the standard value of 0.7 V used for the forward voltage of a conducting silicon diode. Suggest a reason for any discrepancy.

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[2 marks]

Total 16 marks

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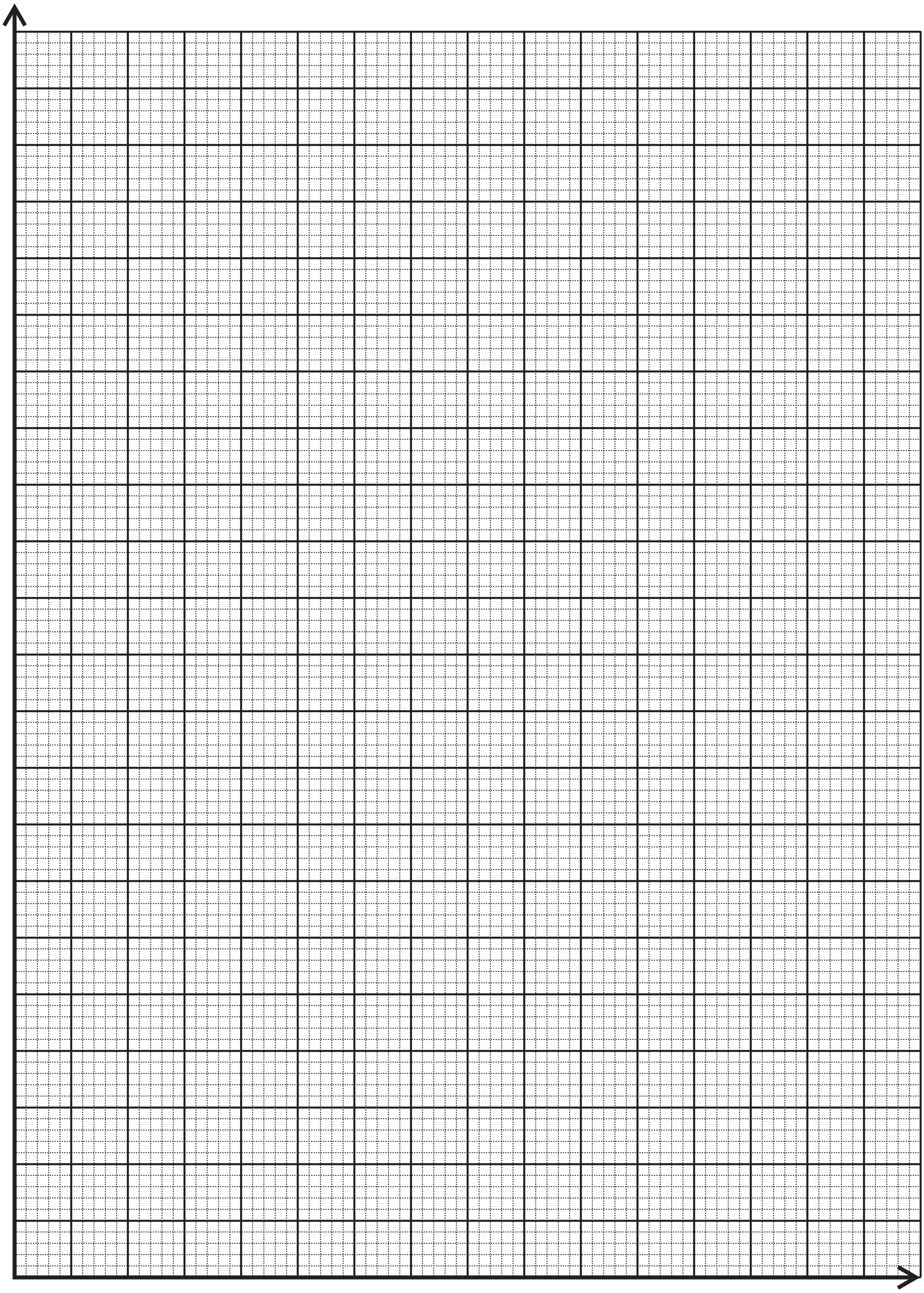

Figure 2. I_D versus V_D

2. In an experiment to verify Faraday's law, an air-core transformer (consisting of two solenoids, an outer one with diameter of 6 cm and an inner one of 5 cm) was mounted concentrically. The outer solenoid formed the primary and was energized with 25 V (rms) 10 000 Hz alternating current from a signal generator. The r.m.s. voltage at the secondary was measured using a digital multimeter. The readings were repeated for several values of frequency taking care to keep the input voltage constant. The results obtained are recorded in Table 2.

TABLE 2

Input Frequency [f_i] (kHz)	**Output voltage [V_0] (mV)**
10	1.38
15	2.10
20	2.78
25	3.52
30	4.17
35	4.93

(a) On the grid provided in Figure 3 **(page 9)**, plot a graph of output voltage, V_0, versus input frequency, f_i, and draw your best straight line through the points. **[6 marks]**

(b) Determine the slope, S, of your graph.

[3 marks]

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Figure 3. V_0 versus f_i

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(c) Given that the relationship between the slope (S) and the number of turns of the secondary (N_2) is $S = kN_2$, where $k = 7 \times 10^{-10}$, determine the number of turns on the secondary winding.

[2 marks]

(d) Describe the effect on the voltages recorded in Table 2 if the radius of the inner solenoid were increased. State a reason for your answer.

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[2 marks]

(e) If this experiment were carried out using an oscilloscope to read peak-to-peak voltages, would you expect the result to be different? State a reason for your response.

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[3 marks]

Total 16 marks

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3. For this experiment you are required to design a laboratory activity to teach a group of CAPE students how to

- use an integrated circuit to demonstrate some of the properties of the D flip-flop
- connect several flip-flops to form a binary counter.

You are provided with two 7474 integrated circuits as shown in Figure 4 and a pin connection data sheet.

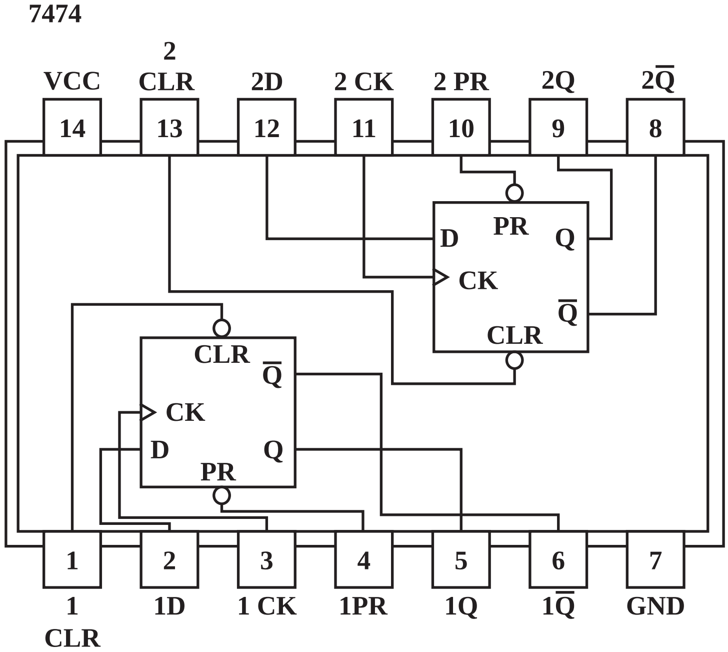

Figure 4. Integrated circuits

(a) List the additional pieces of equipment required in order to verify that any one of the flip-flops in the 7474 operates as a triggered bistable when the *Q* output is connected to the *D* input.

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[2 marks]

(b) Draw the circuit diagram for the D flip-flop operating as a triggered bistable.

[1 mark]

(c) Outline the procedure for verifying the truth table of the resulting triggered bistable.

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[5 marks]

(d) Sketch the expected result as a timing diagram.

[3 marks]

(e) Draw the circuit diagram for a 3-bit binary counter using 3 triggered bistables showing the pin numbers of the connections to be made.

[5 marks]

Total 16 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.